Renewable Energy Development in India

Renewable Energy Development in India:
Analysis of US Policy Experience

Edited by

P Venkata Ramana
Keith Kozloff

Tata Energy Research Institute

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Preface

The renewable energy sector has changed rapidly since the latter part of 1991, in tune with the ushering in of the process of economic liberalization in India. In 1992, the then Department of Non-conventional Energy Sources was converted to a full-fledged MNES (Ministry of Non-conventional Energy Sources) under the direct charge of the Prime Minister. The same year, the *New Strategy and Action Plan* announced by the MNES envisaged the promotion of various RETs (renewable energy technologies) through commercialization, which till then were promoted mostly through state subsidies. For this purpose, the MNES announced a set of fiscal and financial incentives for users as well as manufacturers. The physical targets for different technologies have undergone a sharp revision upwards. Around the same time, international funding in the form of World Bank and GEF (Global Environment Facility) assistance of nearly US$ 200 million has also been sanctioned to assist the commercialization process of RETs, particularly wind, small hydro, and solar photovoltaics. Consequently, there has also been a major spurt in the interest shown by international organizations to enter into joint ventures with Indian counterparts in establishing manufacturing facilities, and in technology transfer.

The idea of having a joint consultation between US and Indian experts on the policy of renewable energy germinated around the time all these exciting things were happening. The USA has had considerable experience in promoting RETs—the country had a sound research and development base and capital availability, which helped in the growth of an established industry; and both federal and state governments provided policy support to assist the RETs. This process has thrown up several positive and negative experiences in dealing with the challenges, and it was felt that India, which has been poised to follow a similar route, would benefit from the feedback.

The WRI (World Resources Institute), in collaboration with TERI-NA (Tata Energy and Resources Institute-North America) undertook the task of identifying participants from the US who have had direct experience in either formulating or implementing policy tools to promote RETs. TERI (Tata Energy Research Institute) conducted a similar exercise to identify the

Indian participants. The final list of participants, which included policy-makers, industry, state utilities, energy development agencies, financial institutions, academic and research institutions, and independent consultants reflects the balance sought to be brought into the dialogue. The US participants were sponsored by USAID (US Agency for International Development) and the US Department of Energy. The MNES, which has been in the process of preparing a renewable energy legislation to be introduced in the Indian Parliament, provided generous financial assistance to conduct the workshop.

Background papers on the status of and various issues concerning the renewable energy sectors in India and the USA were commissioned prior to the seminar, and were distributed to some of the participants. Apart from the commissioned articles, a lot of material already available on the subject was also given to all the participants (see Appendix).

The seminar itself was designed in a unique fashion. It was divided in two parts and conducted over four days, with a gap of one day in between, at two different venues. In order to derive the best out of the dialogue, the first part of the seminar, conducted in Agra on 27 and 28 January 1995, was limited to about 30 carefully chosen and invited experts. The intense discussions that took place in Agra resulted in the formulation of specific suggestions and policy guidelines. These in turn were presented and discussed in a one-day seminar in New Delhi on 30 January 1995 which was attended by over 90 participants. The two-step process adopted for the seminar helped in relevant policy formulations which were finally presented to the Minister of State for Non-conventional Energy Sources, Government of India in the presence of the US Ambassador to India. The Minister reacted to the seminar recommendations by announcing the intention of creating a separate cell in the MNES, which would work on policy-related matters in the renewable energy sector.

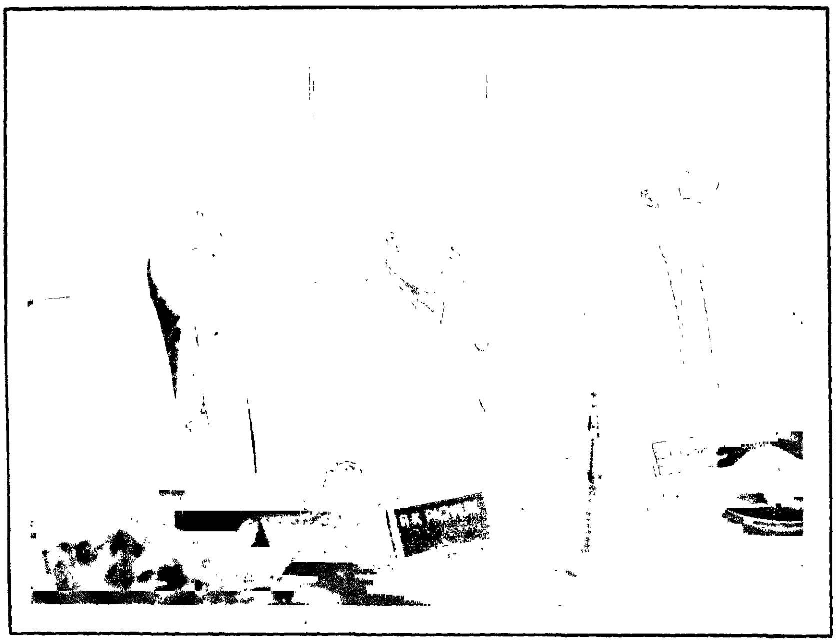
Since the seminar, several events have taken place to demonstrate the seriousness with which the MNES has been acting to promote RETs, and the willingness of USA to continue the partnership. Firstly, the MNES declared a *Solar Energy Enterprise Zone* covering the desert region in the state of Rajasthan, in order to give a specific thrust to realizing the enormous potential, where power generation systems based on solar-thermal as well as solar-photovoltaic technologies have been mooted with international collaboration. Secondly, following up on the Minister's announcement at the seminar, the MNES created a separate cell in the Ministry for policy and planning which would be responsible for coordinating the formulation of the national renewable energy policy, and the legislation to be introduced in the Indian Parliament.

Another significant development has been the expansion of the scope of rural electrification by including decentralized power generation through RETs. Hitherto, rural electrification meant extending the grid and nothing else. Thus, the recent move on the part of the REC is in the right direction, and especially beneficial for remote and inaccessible areas.

The American trade mission led by Ms.Hazel O'Leary, Secretary, Department of Energy, visited India in February 1995 for the second time in one year resulting in several joint ventures and collaborations in the field of RETs. At the same time, creation of REPSO (Renewable Energy Project Support Office) at the Indian mission of the USAID also indicated the US resolve to continue her support to the renewable energy sector. International interest in various renewable energy options, especially in wind, continues.

The other developments have been the much-debated deal of the Enron Power Corporation for setting up a thermal power plant in Maharashtra which was scrapped due to severe political opposition. This has left the future of foreign investment portfolio in the Indian power sector, including that in the renewable energy sector, somewhat uncertain. The initial joint venture with the Amoco-Enron consortium for setting up of a 150 MW solar-photovoltaic power plant in Rajasthan has been repudiated, and a fresh invitation has been issued for international competitive bidding for the project. Thus, political compulsions still continue to play a major role in such ventures.

Nevertheless, it is clear that an impetus has been given to the renewable energy sector in the last few years which is likely to grow in the future. A Parliament-approved legislation, and a national renewable energy policy would go a long way in creating a 'level playing ground' for RETs to make a significant contribution to the overall energy scenario in an environmentally sustainable manner. The seminar and its conclusions are but a part of this process.



Inaugural session of the Delhi Seminar
Left to right: Dr R K Pachauri (Director, TERI), Mr L M Menezes (former Secretary, Ministry of Non-conventional Energy Sources), and Dr Keith Kozloff (World Resources Institute)

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We gratefully acknowledge USAID (US Agency for International Development) for their financial support and the MNES (Ministry of Non-conventional Energy Sources) for conducting the seminar and publishing the proceedings. We would like to thank the World Resources Institute, Washington, DC for the organizational and intellectual support. M/s JPS Associates, New Delhi, kindly provided the logistical support for the seminar.

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SECTION A

Workshop recommendations on the renewable energy policy in India

In the inaugural session of the seminar, participants from the MNES (Ministry of Non-conventional Energy Sources) suggested that deliberations should not be confined to the policies on RETs (renewable energy technologies) for power generation alone (though the experience in the US has been mostly in the power sector), as the rural and decentralized applications of RETs played, and would continue to play, a very important role in India. Therefore, the policy recommendations should adequately reflect these sectors as well. Consequently, the seminar discussions focused on three distinct themes: (i) grid-interactive power generation; (ii) distributed utilities and demand-side management; and (iii) decentralized rural energy applications.

Based on the deliberations, a brainstorming discussion was held during the final session of the seminar, from which the recommendations were derived. The main objective of this session was to put together as many ideas as possible without going into full details. For this purpose, the participants formed three different groups to discuss the three themes and arrive at specific suggestions. Obviously, there is a need to refine these suggestions further and prioritize them before they could be accepted as policy recommendations.

Renewables for power generation

Legislative/regulatory policies

Presently, neither the laws and regulations governing power generation and distribution [Indian Electricity Act, 1910; Electricity (Supply) Act, 1948], nor the periodic modifications effected in these laws, explicitly mention or encourage renewable energy sources (possibly due to the fact that RETs had not been on the agenda till recently). Moreover, isolated power options (except in the case of captive power for non-utilities) are also not covered by these laws.

Therefore, there is a need to introduce regulatory measures if RETs have to have a level playing ground in the short and medium terms. The following options could be considered:

Option 1. Seek an amendment of the existing Acts, Bylaws, etc., to make it mandatory for the utilities to purchase power from qualifying RET projects, public or private, at appropriately designed rates.

Option 2. Introduce a new Bill providing for renewable energy exclusively and in totality so that it is not governed by the existing Acts. This, apart from providing statutory guidelines for utilities on purchasing the RET-produced power, will also aid rural electrification through stand-alone RET projects in remote and inaccessible areas.

Institutional policies

A number of steps need to be taken by the Central and state governments to effect institutional changes for promoting RET-based electricity generation:

1. An institutional mechanism should be created at the national level to coordinate the dialogue and generate a consensus among the various interest groups (Central and state ministries, SEBs (State Electricity Boards), public and private utilities, nodal agencies for RET promotion, industry, NGOs (non-governmental organizations), research institutions, financial institutions, etc.) on devising policies to overcome technology-specific barriers. Such a mechanism could be situated at a central apex body like the Planning Commission, or at a non-governmental neutral organization.
2. Procedures for various clearances needed for setting up RET-based power generation facilities should be minimized and simplified so as to attract private entrepreneurs. For instance, clearances required from various ministries and agencies (technical, financial, environmental, etc.) could be taken up at a single window to ensure swift action. Possibly, an organization like IREDA (Indian Renewable Energy Development Agency) could play such a role.
3. Renewable energy equipment should be treated at par with that of pollution control to be extended concessions and exemptions from various taxes and duties. While an incentive package for RETs is already in place with respect to excise, customs duties, etc., a proper review of the package should be taken up to rationalize it. For instance, the benefit of 100% accelerated depreciation should be extended to mini–micro hydel technology (isolated as well as grid-interactive).
4. Intensive training and awareness creation programs on various aspects of RETs should be undertaken. These programs should aim to bring about a change in the 'mindset' of the conventional power sector. The

target group for such programs could include the Ministry of Power, Central Electricity Authority, public sector power companies (NTPC, PGCI, etc.), SEBs, private utilities, urban development and housing bodies, etc.

Pricing policy

Currently, different SEBs offer different prices for purchasing power from different RETs which range from Rs 1.75 to Rs 2.25. These rates were negotiated exclusively for each RET between the MNES and respective SEBs. However, in order to create a level playing ground for the RETs, an attractive uniform pricing policy for RET-based electricity on a rational basis should be devised. One of the following options could be considered in determining the price:

Option 1. Avoided capacity and energy cost of fossil-based electricity from the last project either installed in that year, or cleared by the Central Electricity Authority, adjusted for the commissioning year.

Option 2. Avoided energy cost of fossil-based power plant either installed in that year, or cleared by the Central Electricity Authority, adjusted for the commissioning year plus capacity cost of RET.

Option 3. Technology-specific two-part tariff based on the cost of supplying electricity from that technology. That is, thermal power and RET-based power could be charged according to their generation costs proportionate to their supply.

Each of these options, however, needs to be studied carefully for their suitability before the pricing policy is formulated.

Demand-side management/distributed utilities (DSM/DU)

The concept of DSM in India is of recent origin and stems from the realization that conserving energy is more effective than adding more capacity. Similarly, DUs which aim to minimize T & D (transmission and distribution) costs through multiple modular power plants of small capacity connected through subgrids and minigrids, is also being talked about only recently. Conceptually, it appears desirable to promote these two approaches by actively encouraging them. The following are some recommendations that apply to both, but mentioned separately when they apply to only one approach.

Legislative/regulatory policies

1. Market forces should be actively encouraged in generation, transmission, and distribution by effecting suitable additions/changes in existing Acts and Bylaws or by introducing a new legislation. Such a regulatory mechanism would help in creating a demand–pull for the technologies or approaches (e.g. making solar water heating or air heating systems mandatory in public buildings).
2. The current mandate of SEBs should be broadened to include DSM/DU measures (which presently do not find mention directly), especially in their future assets.
3. DSM/DU options should be made a part of all power investment decisions. In that sense, the approach should be more of IRP (Integrated Resource Planning) which would ensure inclusion of cost-effective application.
4. Viable DSM options should be made mandatory in new public buildings and private houses constructed by public and private organizations (e.g. solar thermal water heating systems, passive solar architecture, etc.).
5. Cess should be levied on all private conventional power to fund research and development work in DSM and DU in order to improve technology and reduce costs. Such a cess could be collected by the SEB, a part of which could be centralized and governed by an agency like the CASE (Commission on Additional Sources of Energy), or in the case of DSM, a new organization.

Institutional policies

1. The government should establish model projects in each of the states in order to demonstrate the efficacy of the concepts of DSM and DU and create a positive environment for their promotion. The MNES could take the lead in setting up DU projects based on RETs, while the EMC (Energy Management Centre) could be responsible for DSM projects.
2. An active campaign should be taken up by the MNES and MoP (Ministry of Power) to solicit support from the Planning Commission, state governments, financial institutions, and multilateral agencies such as the World Bank, UNDP (United Nations Development Program), etc., to promote DU and DSM programs, respectively.
3. Liberal fiscal and financial incentives should be provided for DSM and DU options. These could include various tax credits/concessions, guarantee returns on private investments, rebates, soft loans, transparent subsidies, etc. The incentive package should reflect concessions offered to the different players involved. For instance, benefits from sales and excise concessions should reflect in the final price paid by the consumer;

tax rebates and accelerated depreciation should be provided for capital investors; customs duty relief should be passed on to the manufacturers, and so on.

4. Attractive public awareness campaigns should be launched to encourage entrepreneurship and establish markets for DSM and DU options. The MNES and EMC should take the lead in this for DU and DSM respectively, and use professional experts for effective promotion.

Decentralized rural energy options

Energy requirements in rural areas are very different from those in other sectors. Cooking and lighting in the domestic sector form the largest energy end-use. Irrigation in agriculture and motive power in small industry are the other important requirements. Rural energy options based on RETs are energy-efficient and environmentally sustainable, and could be individual household-based (e.g. biogas digester) or community-based (e.g. photovoltaic street-lighting). Thus, while the concepts of DSM and DU are well-defined, rural energy options are mostly custom-made (and could include DSM and DU). India has a long history of rural energy programs; however, there is a need to take a close look at the methods of implementation.

Legislative/regulatory policies

1. Rural energy programs based on renewables should be declared as a priority sector at par with other social welfare programs to facilitate support and attention from national and international agencies.
2. Rural energy programs should be integrated with other development programs for mobilizing larger resources. For instance, biogas plants and improved cookstoves could be an integral part of the rural housing schemes; biogas plants could be part of rural sanitation programs, solar pumping systems could be part of irrigation plans, etc.
3. A new legislation should be formulated to give active encouragement to decentralized RET options in terms of licensing, land regulations, incentives, etc.

Institutional policies

1. Rural Energy Enterprises (REEs) should be created/identified at the village or block level to design and implement the rural energy dissemination programs. The state energy nodal agencies, in collaboration with their counterparts in the respective Rural Development Departments, could be made responsible for this. These REEs could be individual en-

trepreneurs, business groups, village *panchayats* (councils), rural cooperatives, or non-governmental/voluntary agencies.

2. Fiscal and monetary incentives available to renewable and conventional power should be extended to REEs with appropriate modifications through a suitable central legislation/regulation (e.g. rural credit on soft terms).
3. Training and project management support should be provided to the personnel of REEs. Entrepreneur development institutes, state administrative training institutes, state planning boards, etc., should be equipped to impart this support.
4. The MNES should provide additional support, including R D & D (research, development and demonstration), for successful implementation of REEs to make them self-sustaining in the long run.
5. Institutional mechanisms should be developed for ensuring standard (quality) equipment, adequate training for O & M (operation and maintenance), financing, and optimal utilization of all resources. (For instance, one mechanism could be incentives to attract rural entrepreneurs to invest in creating O & M infrastructure.)

Conclusion

The above recommendations and suggestions aim to cover various aspects relating to the promotion of RETs. Of these, the ones dealing with legislation and regulation need to be taken up for scrutiny on a priority basis so as to contribute to the ongoing efforts at the MNES to formulate a draft legislation, and a national renewable energy policy. In view of the socioeconomic diversity that exists in different parts of the country, it is also necessary to prioritize the recommendations according to the location or region-specific conditions.

Achieving India's potential for renewable electricity: policy lessons from the United States

Keith Kozloff

This paper[1] summarizes some lessons learnt from the US renewable energy policy and applies them to policy development in India. The first section presents the rationale for bilateral cooperation in developing a renewable energy policy; the second section summarizes relevant lessons learnt from the US experience; and the third recommends various steps to be taken by the US and Indian governments for further cooperation in policy development.

Rationale for bilateral cooperation

A key premise of the workshop is that the successes and failures experienced by the US in addressing barriers to commercializing and deploying renewables provide relevant insights into the challenges of addressing similar barriers in India. In general terms, several barriers to diffusion of renewable energy technologies faced in the US and India are similar: in both countries, distorted price signals bias energy decisions by power suppliers and energy users toward conventional supply options, as do utility decision processes for acquiring generating capacity. Potential cost reductions from scale economies have not yet been fully realized. Each country's policy responses to these barriers have, nevertheless, been conditioned by their respective political and economic systems.

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[1] This paper was prepared in consultation with the US and Indian experts on the renewable energy policy that culminated in a workshop in early 1995. Portions of the paper are based on presentations and discussions at the workshop as well as on other information exchanged before and after it.

There are important similarities and differences between the two countries that should guide bilateral cooperation in policy development. Both countries by now have accumulated sufficient experience to learn from each other's policy successes and failures. Because several renewable electric technologies have experienced major cost decreases, market niches in both countries that had previously been unavailable are opening up. Individual technologies are being demonstrated in an increasing range of applications. Movement toward commercial maturity has been possible partly by the countries' strong scientific and engineering bases. In addition, both countries increasingly recognize the environmental and social benefits of reducing dependence on fossil fuels for future power capacity expansion. Both countries explicitly divide authority over setting the power sector policy between the Central and state governments.

The two nations' respective ongoing sectoral restructuring (particularly the erosion of vertically-integrated monopoly control over power generation) offers both challenges and opportunities for altering the way that electricity services are provided. On the one hand, independent power developers are increasingly able to access transmission grids and sell power to utilities. On the other hand, independent developers have generally favored fossil fuel generation options in both countries.

There are obvious differences between India and the US in the institutional structure of their respective power sectors and the challenges each faces, particularly in meeting capacity expansion needs over the next decade and in how load patterns are spatially distributed. While private power companies exist in India, the power sector is dominated by government utilities. The reverse is true in the US, with consequent differences in incentives and potential points of policy leverage. The demand for power in the US is growing slowly and its utilities have little difficulty in meeting the demand for reliable service, while the capital and managerial problems facing India's rapidly growing power sector are far more severe. India's near term market for renewables may be better than in the US because the high cost of extending the grid to unelectrified rural areas makes off-grid systems more cost-competitive. Thus, India might do better to adapt the 'distributed utility' model than to follow the US model of central station power. Even grid-connected renewable capacity may be more cost-competitive in India than in the US where the marginal cost of new natural gas generation is often less than 4 cents/kWh.

Another difference is that the cost of electricity services comprises a much smaller fraction of total outlays in various sectors in the US than in India. While consumers in the US have demonstrated some willingness to pay a premium for 'green' power, most Indian consumers are not willing to pay.

Lessons from the US experience[2]

As the US policy has evolved since the 1970s, criteria for its effectiveness have come to focus increasingly on stimulating markets that can sustain themselves without indefinite government support. The US experience offers several lessons concerning commercialization strategies, power sector reform, and subsidies. As the GOI (Government of India) broadens and consolidates its policy toward renewable energy, these lessons should be kept in mind.

Target commercialization strategies to technology-specific barriers

Renewable energy technologies are heterogenous not only with respect to the energy services they provide, but also with respect to their level of technological and commercial maturity. Policy interventions and tools need to be closely matched to each technology's characteristics and barriers. For example, some technologies might be best assisted in achieving cost competitiveness through investments in R & D, whereas other technologies only require that their benefits be fully valued by potential purchasers and users. Prioritizing barriers and designing and implementing the policy interventions to overcome them are tasks that must involve key stakeholders from the public and private sectors. Realistic objectives and milestones need to be established with program monitoring and evaluation built into the process from the beginning.

A related issue is the importance of coordinating the policy tools implemented by different public agencies. Individual policies, however well-intentioned, may be ineffective if not coordinated and implemented in a manner consistent with long-term commercialization objectives. The US experience with solar trough commercialization is a case in point (see Box 1).

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[2] Analysis of the US policy experience is based on Kozloff, Keith and Dower, Roger, 1993. *A New Power Base: Renewable Energy Policies for the Nineties and Beyond,* World Resources Institute, Washington, DC; and a forthcoming WRI report on sustainability in the US power sector.

Box 1. Policy lessons from solar trough commercialization

After dominating the solar thermal electric industry for 11 years, investing one billion dollars in its plants, and emerging as the sole supplier of parabolic troughs, Luz International, Ltd. declared bankruptcy in late 1991. A foreign company bought its assets. Nine plants in California's Mojave Desert still produce 354 MW of electricity for sale to Southern California Edison.

The drying up of construction financing, exacerbated by high venture capital interest rates, and the fact that Luz was highly leveraged contributed to the bankruptcy. But Luz's demise raises broader questions about the effectiveness of individual tax incentives, public R & D, and utility purchase requirements in the absence of an overall commercialization strategy.

Early on, Luz enjoyed attractive buy-back rates from the local utility, the fruits of federal solar thermal research, and federal and state tax incentives that sheltered it from market pressures. In fact, tax credits were so generous that early investors netted handsome returns through tax benefits alone. But depending on tax benefits to obtain financing made Luz vulnerable because its electricity was not price-competitive without them. Delays in extending the California property tax exemption played havoc with financing for later plants, and Luz had to pay vendors premiums to meet tight construction schedules. In the end, tax credits and property tax exemptions may have been counterproductive because they were not stable and predictable.

Luz had other problems, too. Early utility contracts, which fixed payments for a decade, were predicted on high energy prices. When prices tumbled by 78% during the mid-1980s, contracts with the utility for new projects exposed Luz's investors to price risk, and the returns they required on investments jumped from 14% to 17%. Over the same period, tax support was cut in half. With tax incentives and regulations that established contract terms insensitive to energy price swings, the technology was prematurely exposed to market forces.

Finally, there was no national strategy for boosting renewables. The cost of electricity from the Luz plants dropped from $0.24/kWh to an estimated $0.08/kWh between 1984 and 1990, and was expected to eventually fall to $0.05/kWh. Had a commercialization strategy been in force, the government might have decided that it was worthwhile continuing to support this technology's development if the technological advances made during that time would drive down costs. But no such strategy existed, and the firm went bankrupt. Since then, no new core of US private sector investment in solar trough development has coalesced. The Luz experience teaches that even well-intended policies may be counterproductive unless they are coordinated and implemented consistently, with an eye to meeting strategic goals.

Integrate renewables into power sector restructuring

In the US, the 1978 PURPA (Public Utility Regulatory Policy Act) broke the power generation monopoly and created markets for renewables by requiring utilities to buy power from qualifying renewable projects at the utilities' avoided costs. However, the future effectiveness of this law in stimulating new renewable capacity is in doubt. Concerns of overcapacity have led some states to implement 'all source' competitive bidding for new capacity. Unless these bidding schemes give points for non-price attributes, renewables are rarely chosen.

The push for greater wholesale and retail competition stimulated by the 1992 Energy Policy Act has dampened utility interest in acquiring anything but the cheapest short-term busbar cost capacity. As a result, the state of California's process for utility acquisition of renewable capacity has recently been challenged by utilities in that state as well as by FERC (Federal Energy Regulatory Commission). Renewable set-asides in New York and Iowa are also being challenged. (See Annexure A for more details on US restructuring status.)

Renewable energy technologies have several characteristics that may not be fully or fairly considered in a restructured power sector, depending on how the restructuring process is guided by the US federal and state policy. These characteristics include environmental benefits, lowered lack of fuel price risk, potential for future capital cost reduction, capital cost rather than operating cost intensity, lack of dispatchability, and modularity (with associated short lead times and ability to be used for distributed applications).

The US experience in private power development to date has exposed both the strengths and weaknesses of establishing capacity acquisition processes for renewables that parallel, but are separate from, those used for other types of capacity. An advantage of doing so is to recognize those characteristics of renewables that utilities are otherwise unlikely to consider fairly. The disadvantages are the risks that renewables will always remain marginal to the utility's decision processes or that the visibility of parallel processes makes them easy targets for attack.

The US participants in the Agra workshop offered a range of perspectives on the importance and wisdom of India implementing the 'must buy' legislation. One participant stated that 'the requirement for the SEBs (State Electricity Boards) to purchase renewable energy should be part of an overall energy policy for India'. Another stated that rather than imposing a mandate, it would be more productive to create incentives for the SEBs to adopt and promote policy guidelines already established by the MNES (Ministry of Non-conventional Energy Sources). A third maintained that such a requirement should be established only in the context of promoting overarching national goals: rural electrification, rural economic development, and mitigation of environmental and energy security risks.

Before creating parallel processes for acquiring renewables, existing biases in power planning and technology evaluation procedures should be corrected as much as possible to be 'technology neutral'. For example, all generation investments involve various risks throughout their life-cycle (construction, fuel cost, operating performance, environmental, etc.). In order to fairly compare alternative generating technologies, these risks need to be treated consistently across generating options in terms of how they are quantified and who bears them. Some US utilities have adopted approaches to resource acquisition that explicitly account for future risks.

Ensure that renewable and energy subsidies induce commercialization

It is difficult to craft subsidies for renewables (or any targeted technology) that cost-effectively achieve commercialization objectives. Cost-effectiveness is promoted, however, when subsidies are designed to have certain characteristics. Firstly, a subsidy's design needs to be closely matched to the barrier to commercialization it is intended to overcome. The US now offers identical production tax credits to developers of wind power and 'closed loop' biomass power projects even though these two technologies face very different barriers. While wind projects are relatively well-positioned to benefit from the credit, markets for closed loop biomass power are not being developed. Not surprisingly, the biomass credits will remain undersubscribed until the credit expires. Even wind developers are often ineligible for the full credit because of their financing structure.

Secondly, subsidies need to be implemented consistently, remain in place until the stated commercialization objectives are achieved, and then phased out in a transparent manner. The year-to-year extension of solar tax credits in the US during the 1980s may have done as much harm as good to the solar industry. At the same time, subsidies need to create incentives for technological and cost improvements, as is the case when the size of the subsidy is geared to the actual energy output. Conversely, subsidies based on the capital cost of equipment may create disincentives for such improvements.

The total financial benefit of all subsidies available to a given project should not completely insulate it from competitive forces, thereby risking the creation of false markets for developing technologies. Some early wind projects and solar thermal installations were attractive to their developers even without producing much energy. By 1985, US solar tax credits appeared to be highly successful in stimulating the solar thermal industry; but the industry collapsed by 1987 after the credits expired.

The risk of stimulating a false market should be carefully considered by the GOI, given that it has relied on subsidies (such as 100% first year capital cost depreciation) to stimulate a remarkable growth in the installed wind capacity (300 MW by end of March, 1995). Consequently, some Indian industries may view windfarm development as more of a tax-saving device than a source of power.[3] The rush to set up windfarms prior to tax deadlines runs the risk of compromising quality and imposing cost premia (similar to the Luz experience). Consideration should be given to phasing out short-term incentives and replacing them with long-term ones like electricity production tax credits.

Of course, enactment of subsidies for renewables to counteract subsidies available to competing energy sources is only a 'second best' solution, even when carefully crafted and implemented. Despite some progress, renewables are still disadvantaged by subsidies to conventional energy sources. For example, agricultural electricity tariffs in three Indian states cover only 9–33% of true costs.[4]

Recommendations for workshop follow-up activities

Most of the following recommendations relate to activities for bilateral co-operation or processes that are intended to promote policy development. While more specific recommendations for policy initiatives and reforms are detailed elsewhere in this book, a few general substantive recommendations for policy change are included here. Where appropriate, an implementing organization is identified.

Continue and expand the bilateral policy dialogue

While the interaction between the Indians and Americans was quite fruitful, it ended at about the point when each side had gained sufficient understanding of the other's policy opportunities and constraints to make the most effective contributions. Moreover, the policy situation in both countries is changing rapidly. Assuming that the GOI remains interested, the USAID (US Agency for International Development) should consider supporting further Indo–US dialogue. If opportunities for further dialogue are developed, the types of Indian stakeholders represented need to be broadened. In addition to the MNES as the primary audience on the Indian side, the USAID should establish or reinforce dialogue on renewable energy policy with other ministries (such as the Ministry of Power where contacts have already been established as a result of the USAID's Indian Private Power Initiative).

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[3] Jayaraman N, 1995. Turn, turn, turn—Making Energy is a Breeze in Southern India. *Far Eastern Economic Review*, March 30; D'Monte D, 1995. Indian Wind-Energy Developers Chided for Underestimating Tasks of Windfarm. *The Solar Letter*, June, p. 191.

[4] Bhattacharya S C, 1995. Estimation of Energy Subsidies and Policy Implication of Their Removal: A Case Study of India. Proceedings of 18th Conference of the International Association for Energy Economics, July 5–8, Washington, DC.

Convene collaboratives among Indian stakeholders

The GOI should convene collaborative dialogues among key Indian stakeholders to generate a consensus on how to overcome market and policy barriers affecting specific renewable technologies and build broader constituencies for overall sectoral reform. Such collaborative processes would focus on a defined set of policy issues, meet for a specified period of time, and work toward developing a consensus document or statement. Experience with similar US collaboratives suggests the value of identifying a neutral, independent organization that has the skills to build consensus among diverse groups. Such an organization could be from the public, private, or nonprofit sector. Another critical factor to the success of US collaboratives is that the participants are committed to meeting with each other over a long enough period of time to overcome institutional suspicions and minimize posturing.

Participants might be drawn from the following organizations: MNES, IREDA (Indian Renewable Energy Development Agency), Ministry of Power, National Thermal Power Corporation, Central Electricity Authority, Power Grid Corporation, Central and state government ministries with responsibilities that make them potential users of renewable energy technologies (health, education, telecommunications, housing), SEBs, state nodal agencies, private sector firms (equipment manufacturers, installers, project developers, commercial banks and other financial institutions, trade associations), NGOs (environmental and consumer advocacy groups, rural development NGOs and cooperatives, academic and professional societies), district rural development agencies, and *panchayats*.

If the GOI is interested in establishing policy collaboratives, the US government could provide information about experience regarding the different US models for national or regional dialogue on renewable energy policy that have been implemented. Topics addressed by these groups include technology commercialization strategy, sustainable biomass feedstock production, and electricity sector restructuring. In addition, the experience that the US-based NGOs have had in developing renewable stakeholder groups in Latin America might be examined for possible adaptation.

The following candidate issue should be considered as an initial topic of a policy dialogue: How can renewables be integrated into India's power sector restructuring process? The unfolding US experience suggests how an institutionally restructured power sector can have profound effects on how electricity service needs are met; in particular, restructuring affects incentives for alternative energy supply and demand choices and investments. For example, some types of restructuring may favor a more decentralized model for providing electricity services than others. The economic incentives of the new set of players for choosing renewable or non-renewable options may be quite different than those prior to restructuring. Because India has not yet gone far in its restructuring process, it can benefit by addressing these issues now.

Explore alternative institutional arrangements

By explicit design, policy authority for renewable energy is outside the organizational structure of India's conventional power sector. While this decision puts renewable energy at the same institutional level as conventional energy sources, it removes the responsibility to consider renewable options from the Central government agencies that are part of the existing system (Power Grid Corporation of India, National Thermal Power Corporation, Rural Electrification Corporation, Central Electricity Authority). A similar tradeoff exists for the nodal agencies for renewables at the state level.

The existing energy policy framework is characterized by fragmented responsibility and inadequate coordination among some agencies responsible for major power sector investments. For example, the current institutional framework does not promote a comprehensive approach to village power systems using renewable/non-renewable hybrids nor does it promote end-use analysis of energy needs to determine the conditions under which renewables are the most cost-effective option. Moreover, the respective roles of the Central, state, and local (district and block) governments are not well defined. Since the MNES is a relatively small player in formulating a national energy policy, other ministries and the private sector must 'buy in' to whatever policy proposals emerge from the MNES. Without a broad-based political constituency for reform, little will happen.

Institutional restructuring options are as follows:

- unify energy policy at the national level, under one ministry with renewables assigned a comparable status in the policy-setting process to that of other energy sources. Some responsibilities of the MNES for program implementation might be devolved to state agencies;

- reinvolve SEBs at the state level in renewable energy programs (including distributed utility and demand-side applications) as part of the restructuring of their responsibilities;
- create horizontal linkages between renewable energy and integrated rural development programs;
- integrate renewables into rural electrification programs; and
- strengthen public/private renewable energy joint venture capability, e.g. by using the public corporation status of some state nodal agencies.

Improve policy cost-effectiveness by ex-ante market research, program monitoring, and ex-post evaluations

The newly-created policy analysis cell within the MNES should be carefully positioned and given ample resources and visibility to be an effective voice to improve policy cost-effectiveness. In addition to addressing the other issues raised in this paper, the cell's responsibilities should include analyses of new policy proposals, and evaluation of existing programs. It should bring a high degree of intellectual rigor, transparency, and independence to program evaluation.

Given the existing set of policy tools, an early task of the cell might be to evaluate their cost-effectiveness in commercializing renewables and, where necessary, recommend changes or new initiatives. Design and implementation issues that should be examined include:

- consistency and predictability in implementation as well as sunset provisions that are tied to explicit goals;
- rewarding technology improvement and cost reductions, e.g. by basing subsidies on energy produced rather than capital cost;
- matching the type of subsidy to the particular barriers facing a given technology;
- avoiding the creation of 'false' markets by shielding a technology from all competition; and
- targeting the subsidy to the decision-maker whose incentives need to be changed.

The US experience has much to offer in evaluating alternative commercialization incentives. These have yet to be fully incorporated into the Indian policy analysis. For example, the US has some experience in making subsidies available to different stakeholders (consumers, equipment suppliers, utilities). The US experience in renewable energy policy analysis, auditing and monitoring, and program evaluation could be tapped through written materials, training and seminars.

Integrate renewables into ongoing SEB restructuring efforts

The attention of SEB managers is generally commanded by more pressing political, financial and managerial problems than how they might integrate renewables into their power-mix. These problems include inadequate revenues to recover their cost of service (because tariffs are set below marginal cost and collection rates for some classes are very low[5]), poor labor productivity due partly to a surplus pool of civil service personnel (that will only be exacerbated as conventional power generation responsibilities shift to the private sector), political pressure to extend electricity services to currently unserved or underserved villages and households, poor service reliability, and T & D (transmission and distribution) energy losses as high as 45%. Efforts required to make the SEBs embrace renewables as a power option (such as mandatory purchase at minimum rates) is likely to be resisted or met with indifference unless the SEBs come to view renewables as an aid to address their problems.

The chronic crises facing the SEBs may offer opportunities for the GOI to offer win–win incentives for redirecting SEBs' technical and financial resources to implementing renewable solutions to grid-extension needs. States that have moved the furthest toward unbundling and allowing competition in providing electricity services might be good starting points (i.e. Orissa, Haryana, Uttar Pradesh, and Rajasthan).

One approach might be to promote the creation of RESCOs (rural energy service companies) that would identify, implement, finance, and service DSM (demand-side management), DU (distributed utility), and off-grid least-cost energy supply options. The components of the concept are as follows:

- Develop a training program (in cooperation with civil service unions) to retrain SEB engineers and other personnel in exchange for early retirement. The training would include identifying, implementing, and servicing off-grid options to grid-extension as well as DSM and DU applications of renewable and non-renewable technologies. Training would also include business management skills. Direct training and related costs would be picked up by the Central government. In order to qualify for funding from the Central government, the SEB must adopt an integrated least-cost approach to acquiring new resources to meet the power demand, and begin to rationalize its tariff structure.

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[5] According to the seminar participants, a significant segment of the rural population would be willing to pay the real costs of reliable electricity services.

- The retrained SEB personnel would form for-profit RESCOs that work with rural development agencies, *panchayats*, agricultural cooperatives, or other organizations in coordination with the SEB to develop renewable energy projects. For example, wind or photovoltaic-powered high efficiency water pumps might be used to serve the growing demand for irrigation services or replace inefficient diesel or electric pumps. The RESCOs would be allowed to collect costs from rural customers comparable to what the utility avoids by not having to serve the customers directly through grid-extension.
- Either the RESCO, SEB, or customer could potentially own the equipment. Each option has advantages and disadvantages. The SEB could use its access to relatively low cost capital for equipment leasing, purchase, or capitalize revolving loan funds. The IREDA funds might also be made available to RESCOs. If off-grid project equipment is owned by a RESCO, the SEB would be relieved of the responsibility for tariff collection.

There are other possible mechanisms to create politically viable solutions, all of which would need to be developed further. The SEBs could be allowed to create internal profit centres that compete to provide least-cost rural electricity services with conventional grid-extension.

Another approach, which does not require tariff reform, would be to structure mechanisms for other sorts of private firms to invest in DU and demand-side applications. For example, a private industry that wants more power for producing goods than is currently available from the grid might be allowed to make energy efficiency investments for other customers. In turn it would gain access, through the SEB, to the power made available by these investments. Thus, tariff reform need not be a precondition for implementing demand-side renewable energy projects and programs. Yet another approach would be to convert the local biomass feedstocks (i.e. agricultural residues and surplus by-products) to electricity. The resulting increase in rural income could be used to offset a concomitant increase in rural electricity tariffs.

The US state regulators are accumulating experience in crafting policies to encourage utility acquisition of renewable capacity, such as requiring utilities to issue competitive solicitations for renewable power generation. However, the anticipated restructuring of the US utility industry is calling the future effectiveness of these incentives into question. New tools are being examined such as performance-based rate-making (in which financial returns are tied to environmental or other performance measures). Because vertical deintegration of the power sector is further ahead in the US, India has an opportunity to 'leapfrog' (through bilateral exchange) in developing policies to ensure that renewables are fully considered in the power sector.

Implement demonstration projects

The history of the Indian and US wind power development has shown that demonstration projects, in a favorable policy environment, can stimulate replication. Demonstrations, however, need not be limited to hardware. The GOI should provide grants to interested states to demonstrate comprehensive strategies for commercializing appropriate renewable energy technologies. Components of such initiatives might include renewable energy policies, DU and renewable hardware demonstration projects, adaptation of appropriate analytical tools, etc. State-level strategies could be developed through collaboration among the SEB, nodal agency and other stakeholders. The approach of selecting one state initially for pilot demonstration might result in competition among different states by submitting proposals. The selection criteria might include previously demonstrated interest in integrated resource planning, DU applications, and renewable energy technologies, as well as a commitment to sectoral reform and cooperation among public and private stakeholders.

The US technical cooperation might include partnering the SEB with a US utility or state PUC with relevant experience (similar to the model being used in the USEA (Utility Partnership Program). Technical cooperation might also transfer analytical capability in support of the state demonstration. Several planning and analytical tools for evaluating renewable energy applications and investments have been developed by DOE's (Department of Energy) NREL (National Renewable Energy Laboratory), the US utility industry's EPRI (Electric Power Research Institute), and other organizations. The USAID and DOE need to cooperate more closely with each other in working with the GOI, NGOs and the private sector in selecting and adapting these tools. The GOI might, with the US support, solicit multilateral financial assistance for the demonstrations.

Build the constituency for energy pricing policy reform

India's playing field between renewable and non-renewable energy sources is often claimed to be heavily tilted in favor of non-renewables, an assertion used to justify subsidies for renewables. A thorough analysis of the extent to which the current policy favors non-renewables, however, has yet to be conducted. Such an analysis would make hidden subsidies more transparent and thereby allow the trade-offs between the current situation and policy reform (eliminating all energy subsidies) to be fairly debated.

At a minimum, the analysis should examine the following areas:

- tax codes that favor either capital or operating cost-intensive equipment[6] or impose differential customs duties on conventional power equipment and renewable power equipment.
- the 'off-book' costs of any ancillary capital infrastructure required for fossil fuel generation (i.e. fuel processing, transshipment and storage facilities).
- government provided or subsidized (below market rate) services such as for fuel extraction or transportation.[7]
- the extent to which electricity tariffs reflect marginal costs of power generation, including location and time-of-use specific costs.
- the extent to which fossil fuel projects have preferential access to financial subsidies that the GOI offers to the private developers, such as the counter-guarantee system.
- uninternalized economic losses due to air emissions, such as decreased worker productivity, hospital admissions for pulmonary problems, cleaning, structural damage, etc.
- the effect that subsidized energy prices for the farm sector have on excessive groundwater exploitation in rural areas.

To the extent feasible, the analysis should express the quantifiable subsidies in terms of their effects on relative unit cost.

Strengthen bilateral commercialization linkages

In addition to the mutual benefits from policy dialogue, another reason for bilateral cooperation is that the two countries can help each other in overcoming their respective barriers to commercializing renewable technologies. Renewable power developers in India have access to potentially enormous markets, but often lack access to capital and state-of-the-art technology. Firms in the US tend to have better access to capital to continually improve technology, but lack access to large enough domestic markets to warrant investments in expanding production capacity (especially given the US utilities' conservative behavior in expectation of increased competition). Even the ambitious Enron/Amoco Solar proposal to sell PV-generated power at 5.5 cents/kWh from a Nevada-based facility has not yet generated a stampede of orders among nearby utilities.

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[6] A recent study showed that the US tax codes favor the operating cost-intensive characteristics of the non-renewable power sources.

[7] An estimated 24% of India's rail capacity is devoted to moving coal.

A strong bilateral synergism exists between the commercialization needs of the two countries. Various private joint ventures have already been initiated. The two countries, however, have not fully exploited potential opportunities to mutually stimulate technology commercialization. The unsettled US domestic market for renewables (due in part to utility restructuring) and constraints on federal funding for renewables both underscore the importance of a closer linking of domestic programs of both the countries. Benefits to India from close US linkages include increased access to and improved understanding of technologies and applications and, possibly, lower costs of energy from renewables through provision of forward markets.

There are several potential linkages that could be explored involving both private and public participants. One such example is joint sponsorship of demonstration projects in either country. Another is to allow Indian utilities to be included in the US market diffusion programs, such as the DOE-supported Utility Photovoltaic Group's TEAM-UP (Technology Experience to Accelerate Markets in Utility Photovoltaics) initiative. Yet another would be to give the GOI the opportunity to sit on the board of directors of the US or state government programs such as the Solar Enterprise Zone.[8] Finally, the DOE and MNES could collaborate in designing and implementing commercialization strategies for technologies with large markets in both the countries. Elements of the strategy might include joint initial demonstrations, pilot project replication, and structuring forward markets for large scale diffusion.

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[8] In March 1995, the MNES Minister, Krishna Kumar, announced the establishment of a similar solar enterprise zone near New Delhi.

Annexure A

Status of renewable power policy in the evolving structure of the US electricity industry

Prominent among the state-level regulatory reforms in the US is the 'least-cost planning', the notion that utilities should weigh the broadest possible range of resource options in order to choose the resource-mix that meets energy demand at the lowest long-term social cost. IRP (Integrated Resource Planning) is a more recent term for least-cost planning and one that explicitly takes account of demand- and supply-side acquisitions, social costs, and risks associated with resource options, as well as the need for public participation. Although 31 states in the US now require some form of least-cost planning, most do not expressly consider environmental, financial risk, distribution, transmission, and reliability implications of alternative generating technologies.

One of the primary objectives of least-cost planning is to encourage utilities to treat demand- and supply-side resources on an equal footing. Utilities currently spend over $2 billion per year in DSM (demand-side management programs). In some states, PUCs have encouraged these expenditures by decoupling utility profits from unit sales. Under the prevailing regulatory system, the cost-effectiveness of the utility's DSM investments is often measured by the reduction in total costs to the utility resulting from savings in operating costs and capital investments.

At the federal level, the PURPA required the US utilities to purchase power from the qualifying renewable power and cogeneration facilities (QFs) at prices based on their 'avoided costs'. The renewables fared well in the ten states that had favorable buy-back policies and contractual incentives. These states now account for 73% of the nation's QF capacity. By 1991, concerns about cost-effectiveness and overcapacity prompted 36 states to implement competitive bidding among all power sources. But, given the near obsession in competitive bidding on lowest cost per kWh, only 2% of all capacity acquired under such schemes was renewable during 1993 (Box 2).

Box 2. State renewable set-asides

To address the lack of explicit consideration of environmental and other benefits in all-source bidding, some state regulators require utilities to solicit competitive bids for a part of their capacity needs from developers of renewable resources (sometimes called set-asides). One approach is for a utility to issue a 'Green RFP'—a competitive Request for Proposals (RFP) for new capacity limited to renewable resource projects. A Green RFP combines the cost-control aspects of competitive bidding with an RFP's ability to reduce market risks to renewable resource developers. This tool lets developers know that factors other than price per kWh count, and it spares them the high transaction costs encountered in open-ended, all-source bid solicitations. Presently, the New England Power has issued a 45 MW Green RFP; the Bonneville Power Administration has received bids under a solicitation for 50 MW of wind capacity; and the Portland General Electric has announced it will issue a 200 MW Green RFP. The Sacramento Municipal Utility District recently recommended a 350 MW set-aside for renewables and other advanced generation technologies. Other states have also ordered utilities to acquire specified amounts of renewable capacity.

The 1992 Federal EPACT (Energy Policy Act) boosted competition for power generation by relaxing ownership requirements for non-utility generators, and by requiring utilities to provide independent developers with access to transmission lines. Not long after the dust had settled on the 1992 Act, serious proposals began circulating in a few states (notably California and Michigan) for introducing competition at the retail level by giving customers the option of buying power either from utilities other than their local one or from independent generators. Under either option, power generated by others would be shipped over the local utility's lines.

Under California's initial proposal, electricity consumers could retain their traditional relationship with their current utility; directly contract for another service provider; or, contract with a firm that bundles individual customers for power suppliers. Customers could leave or return to their current utility only after a notice period. For its part, the utility retains its obligation to serve only those customers that do not elect direct access, and it can compete for providing service to direct access customers. The utility must provide transmission and distribution services on a nondiscriminatory basis and remains the last resort as an electric service provider. According to other provisions, utilities become subject to performance-based regulation in which allowed returns depend on how well they provide service. Direct access would be phased into different customer classes over several years. As of summer of 1995, the California PUC was considering two restructuring options—a power pooling model and a direct access plan. Both included support for the continued use of renewables by requiring every power supplier operating in California's retail electricity market to build a portfolio of resources consisting of at least 12% renewables.

In early 1995, FERC (Federal Energy Regulatory Commission) issued a 'notice of proposed rule-making' on interstate transmission transactions. Under the rules proposed by the FERC, utilities would be required to unbundle their new power sales and transmission services and take up transmission service under tariffs that hold for any wholesale user. The utilities would file interstate transmission tariffs under which they provide wheeling service to third parties, comparable to the service they provide themselves. Another significant 1995 FERC action is the approval of the nation's first regional utility group to make regional transmission planning more efficient and promote fair terms for transmission access.

Meanwhile, the mandatory purchase provisions of the PURPA have come under increasing attack as some utilities claim they are now saddled with contracts representing excessive and expensive capacity, and that the PURPA has fulfilled its purpose of stimulating competition. Spurred on by the disgruntled utilities, PURPA reform or repeal is being considered in the Congress and before the FERC.

While the PURPA may be ripe for reform, arguments for its repeal are premature. With respect to creating excessive costs, the cost of capacity acquired under the PURPA should be compared fairly with the costs associated to actual or avoided utility investments based on information available at the same time that QF capacity was acquired. With respect to the argument that policy intervention is no longer needed to bring about wholesale power generation, barriers to entry remain for NUGs (non-utility generators). In many areas, the local utility is still the sole buyer of wholesale electricity for distribution to retail customers. Where this is the case, the PURPA's must-buy requirement protects against the utility favoring its own or affiliated generation sources. And while the must-buy requirement has helped established renewable-based generation in many states, markets for most technologies remain unpredictable. Utility-built generation and the NUGs remain subject to different financial performance standards:

- the NUGs must meet strict project development guidelines or post some form of security deposit or insurance. While utilities have much more flexibility, they do not face the same risk of cancellation that the NUGs face,
- NUG contract prices set 5–10 years ago are compared to the cost of power today, while utility plant costs are not held to the same standard.

The typical utility project is not asked to pay refunds if other alternatives turn out to be cheaper,

- the NUGs bid into competitive procurements knowing they will have to bring projects on line within their bid price or risk lower profits, while utilities can bid low, knowing that the obligation to serve offers a regulatory means to collect differences between bid price and the actual project costs, and
- the utilities have preferential access to resources because of being on both the generation and distribution side of the transaction, giving them access to inside information regarding capacity and resource needs.

Regardless of whether the PURPA is reformed or repealed, it is unlikely to induce as much renewable capacity as was added in the 1980s. The QF status still confers benefits to developers of renewable power, but heightened wholesale competition (particularly from natural gas project developers) will dilute its effects. In California (which has the largest QF installed capacity), many projects that are receiving payments based on fixed energy prices now face a price cliff. The capacity and energy contracts under which the QFs sell power to utilities are pegged to prevailing energy prices in their eleventh year, resulting in some cases in a 50–70% drop in energy revenues. Net capacity has actually decreased in the last two years. Biomass capacity alone has shrunk by about 300 MW. Moreover, in 1995, the FERC ruled that the capacity auction process California uses violates the PURPA by causing utilities to pay more than the current avoided costs.

Regardless of the outcome of California's experiment, momentum is building up in at least 30 state PUCs across the country for profound changes in the way that electricity services are provided. As of June 1995, restructuring of proposals were also being discussed in at least 15 state legislatures. In anticipation, electric utilities have already begun to change their policies, giving rise to the term 'virtual restructuring'. The form of the industry that state and federal regulators ultimately approve may vary by region. However, because the rules under which the industry operates in one state will affect electricity suppliers in other states, the federal government is likely to impose some uniform guidelines on the process.

SECTION B

Renewable energy program in India

Venkata Ramana P, Chandra Shekhar Sinha

Although RETs (renewable energy technologies) like biogas plants and improved cookstoves have been available in India since the late 1940s, the renewable energy program started in earnest only with the establishment of the DNES (Department of Non–conventional Energy Sources) in 1982. Till recently, RETs in India have been promoted through demonstrations and R & D projects as well as large scale dissemination of projects/programs most of which were supported by government subsidies and financial incentives.

Though the figures shown in Table 1 appear impressive in themselves, the contribution of renewable energy has been insignificant (not accounting for direct biofuel use in the rural areas) in the overall energy mix in the economy. There are two major reasons for this. Firstly, compared to the conventional energy sources, RETs have, except for a few biomass-based technologies, not been economically viable due to various technological and other constraints (Table 2). Secondly, budgetary allocations for their promotion have been low. Between 1980 and 1992, the cumulative government expenditure in the renewable energy sector totalled Rs 11.55 billion, as against Rs 812 billion in the power sector, Rs 335 billion in the petroleum sector, and Rs 158.5 billion in the coal sector. Even in the Eighth Plan (1992–97), the renewable energy sector was allocated just about 0.8% of the total funds allotted to the energy sector. Another significant factor has been a lack of active linkage with the industry, both in R & D and in application, which would have brought private capital into the sector.

The biogas program was traditionally the single largest renewable energy program, accounting for over half the funds allocated. All other individual programs have received less than 10% of the funds. In terms of numbers, however, the dissemination of improved cookstoves has been the largest followed by the biogas program. Biogas plants and improved cook-

Table 1. Physical progress of RETs in India

Program	Up to March 1994	Up to June 1995
Family-size biogas plants	1.98 million	2.2 million
Improved cookstoves	17 million	19.73 million
Solar thermal systems (collector area)	277329 m^2	296349 m^2
Solar cookers	339,359	372,293
PV (photovoltaic) water pumps	756	1354
PV power units	524.6 kWp	820 kWp
PV community lights/TV and community facilities	884	954
.PV domestic lighting units	32241	67171
PV street lights	28674	32871
Wind pumps	3017	3091
Windfarms	116 MW	366 MW
Mini-micro hydro	110 MW	121 MW
Biomass gasifiers/Stirling engines	14 MW	20 MW

Source: MNES 1995

stoves have enjoyed a fair amount of success and acceptability among rural households. However, there is scope for considerable improvement in the implementation of these programs.

Among other technologies, windfarms have emerged as a viable option in the power sector. With the experience gained in the program, and the growing interest of the private sector in this technology, wind energy can be expected to develop even more in the coming years. Small hydro has evolved as another promising option for electricity generation, especially in remote hilly areas where the cost of grid-electricity is prohibitive. Among solar thermal technologies, water heating systems (for industrial use) and solar cookers are gaining popularity. However, in both these, attention needs to be paid to product development, and they need to be made more compatible with user requirements.

On the whole, though not all RETs are defensible purely on economic grounds as yet, environmental and social concerns, which are of equal importance in view of the need for sustainable development, make a case for their promotion in a country like India. Thus, in order to promote RETs in a systematic manner, DNES was converted to a full-fledged Ministry (MNES) in late 1992. In keeping with the new policy of economic liberalization, the MNES has adopted a comprehensive strategy and action plan for promoting RETs in India. The action plan shifted the focus of the programs

Table 2. Summary of the cost of energy from various technologies*

Technology	Unit	Capital cost (Rs/unit)	Useful life (years)	Capital recovery factor	Annual capital cost (Rs/unit/ year)	Recurring costs		Total annual cost (Rs/year)	Annual generation (kWh/unit)	Cost of energy (Rs/kWh)
						O & M (Rs/unit/ year)	Fuel (Rs/ year)			
CENTRALIZED POWER GENERATION										
Renewable technologies										
Wind farm	kW	30000	20	0.134	4016	1500	0	5516	1752	3.15
Small hydro	kW	30000	30	0.124	3724	600	0	4324	2628	1.65
Coal Thermal	kW	25000	25	0.127	3181	250			4818	
coal cost with transport cost @Rs 0.26/t-km and marginal pit-head cost of Rs 335/t ; PLF 55% coal consumption 0.7 kg/kWh										
	300 km	413 Rs/t					1990	5427		1.13
	500 km	465 Rs/t					2240	5678		1.18
	800 km	543 Rs/t					2616	6054		1.26
	1000 km	595 Rs/t					2867	6304		1.31
DECENTRALIZED POWER GENERATION										
Photovoltaics	kWp	220000	25	0.127	28050	4220	0	32270	1560	20.69
Gasifier										
agro-waste based	kW	10500	15	0.147	1101	950	4415	6466	5256	1.23
wood-based	kW	7500	15	0.147	1101	750	5992	7843	5256	1.49
Biogas dual-fuel	kW	9500	20	0.134	1272	950	0	2222	5256	0.42

(Continued)

Table 2 continued...

Technology	Unit	Capital cost (Rs/unit)	Useful life (years)	Capital recovery factor	Annual capital cost (Rs/unit/ year)	Recurring costs		Total annual cost (Rs/year)	Annual generation (kWh/unit)	Cost of energy (Rs/kWh)
						O & M (Rs/unit/ year)	Fuel (Rs/ year)			
Solar dish stirling	kW	90000	20	0.134	12049	1800	0	13849	1752	7.90
Contribution of distribution line for different distances from the 33 kV grid										
	1 km	43000	25	0.127	5482	2150	—	7632	56940	1.31
	5 km	215000	25	0.127	27412	10750	—	38162	56940	1.85
	10 km	430000	25	0.127	54825	21500	—	76325	56940	2.52
	15 km	645000	25	0.127	82237	32250	—	114487	56940	3.19
IRRIGATION/SHAFT POWER										
Windmill										
shallow well unit		25000	20	0.134	3347	1500	0	4847	1051	5.79
deep well unit		45000	20	0.134	6025	1000	0	7025	1752	5.19
Gasifier										
agro-waste based	kW	12000	10	0.177	2124	1200	3259	6583	2628	2.50
wood-based	kW	9000	10	0.177	1593	1350	5186	8129	3584	2.32
Photovoltaic irrigation	kWp	240000	25	0.127	30600	1000	—	31600		
water supply						(demand restricted to 120 d/y)			624	50.64
					(constant demand throughout the year)				1560	20.26

* Revised version of the table from Sinha C S, 1992. Renewable energy programmes in India: A brief review experience and prospects, *Natural Resources Forum* **16**(4):305–314.

from state-supported development and demonstration activities to commercialization of technologies. The thrust of the strategy now is to provide a conducive policy environment and support mechanisms that would lead to increased participation of the private sector in the utilization of renewable energy technologies.

In order to encourage this process, a package of fiscal incentives and tax holidays has been introduced. The package includes:

- 100% depreciation allowance
- Soft loans
- Reduced customs duties on imported materials and equipment
- Exemption from excise duty and sales tax
- Remunerative price for power fed into the grid, and
- Facilities for wheeling and banking of power

A separate financial institution—the IREDA (Indian Renewable Energy Development Agency) set up in 1987 by the Ministry—plays a key role in implementing this package, by offering loans on soft terms to users and manufacturers of different RETs (Table 3). A few of the state governments and state electricity boards have also adopted guidelines and policies aimed at promoting renewable energy projects in their respective states.

The outcome of these efforts is already becoming visible in the area of power generation, as discussed in the following sections.

Wind power generation

Amongst all the renewable energy technologies, windfarms appear to be the most feasible and cost-effective for supplementing conventional means of power generation on a large scale. Following the energy crisis, wind power generation had a fresh lease of life in California during the late 1970s on the strength of energy diversification policies, tax incentives, private power legislation, and R & D. The performance of the windfarms commissioned in India in the early and mid-1980s established the technical viability of wind turbine technology in the country. The operation of these windfarms gave an average (over a period of five or more years) availability of about 98% and the capacity utilization factor was as high as 30% at some locations.[1]

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[1] Hossain J, 1991. *Strategies for the indigenous development of grid connected wind electric generators in India*, Report submitted to the PACER Secretariat, Tata Energy Research Institute, New Delhi, December.

Table 3. Lending norms of IREDA

S.No.	Sector	Interest rate (inclusive of interest tax) (%)	Minimum* promoters' contribution (%)	Lending norms of IREDA		Repayment	
				Term loan	Ceiling on** Term loan	Moratorium period (maximum) (years)	Total repayment period (maximum) (years)
1	Windfarms	14.5	25	Up to 75% of total cost of eligible items under World Bank loan	—	1	6
2	Small hydro	14.5	25	-do-	—	3	10
3	Biogas generation	15.5	25	60% of total loan amount	Rs 1.5 crores	2	8
4	Biomass utilization	10.3	25	Full loan amount	—	2	10
5	Solar Thermal Systems						
	Manufacturers	15.5	25	Full loan amount	—	2	8
	Users (direct)	10.3	30	Full loan amount	—	2	8
	Intermediaries***	10.3	30	Full loan amount	—	1	8
	Intermediaries@@ (domestic systems)	2.5	30	Full loan amount	—	1	8

S.No.	Sector	Interest rate (inclusive of interest tax) (%)	Minimum* promoters' contribution (%)	Lending norms of IREDA		Repayment	
				Term loan	Ceiling on** Term loan	Moratorium period (maximum) (years)	Total repayment period (maximum) (years)
6	Solar photovoltaics						
	Manufacturers	15.5	25	On project to project basis	Rs. 1.5 crores	2	8
	Users	10.3	25	—	—	i) 2 (SPV power plants) ii) 1 (others)	8
	Intermediaries***	10.3	25	—	—	-do-	-do-
	Intermediaries@@ (domestic systems)	2.5	25	—	—	-do-	-do-
7	Cogeneration for power generation	14.5	25	40% of project cost	Rs 3 crores	3	10
8	Manufacturing of high efficient wood burning stoves	15.5	25	Full loan amount	—	2	7
9	Purchase of biomass gasifier for power generation	12.9	25	Full loan amount	—	2	6 for new units; 5 for existing units
10	Manufacturing of: a) Briquetting Equipments b) Biomass Gasifier	15.5	25	Full loan amount	—	2	8

(Continued)

Table 3 continued...

S.No	Sector	Interest rate (inclusive of interest tax) (%)	Minimum* promoters' contribution (%)	Lending norms of IREDA		Repayment period	
				Term loan	Ceiling on** Term loan	Moratorium period (maximum) (years)	Total repayment period (maximum) (years)
	c) Energy Conservation/ systems/equipments/ devices using/operating through renewable sources.						
	d) Battery Powered Vehicles						
11	Installation of high efficient energy saving/conservation devices/systems through renewable systems/fuels	15.5	25	Full loan amount	—	2	5 for new units; 4 for existing units
12	Purchase of Battery Powered Vehicles based on alternative fuels such as ethyl alcohol (ethanol), hydrogen, etc.	10.3	25	Full loan amount	—	6 months from the date of delivery of vehicle	5

Notes:
- * The minimum promoter's contribution would be 20% of the project cost for SC/ST entrepreneurs.
- ** The ceiling on term loan is subject to further limitations prescribed in the Operational Policy Statement approved by IREDA's Board of Directors as amended from time-to-time.
- *** Are eligible for a spread on interest rate of lending up to a maximum of 4%.
- @@ Interest Rate @ 2.5% would be applicable from the date of furnishing of certificate of installation of domestic systems.
- @ There is a rebate of 0.5% on interest for timely repayment, except for the intermediaries.

As a result of the impressive performance of the initial projects, about 116 MW of grid-connected windfarms were operational with another 58 MW under installation in August 1994. Over 1500 MW are at various stages of planning in the states of Tamil Nadu, Gujarat, Andhra Pradesh, Kerala, Karnataka and Madhya Pradesh. It appears that the Eighth Plan (1992–97) target[2] to increase the installed wind energy capacity by 500 MW, considered to be optimistic by many in the conventional energy supply sectors in India, is likely to be exceeded. The National Wind Resource Assessment Programme of the MNES has identified 77 locations in 9 states with a generating potential of over 4000 MW of grid quality power. India will very soon rank second in the world after the US in wind generation.

Due to the impressive results with the windfarm credit component of the GEF (Global Environment Facility)/World Bank *Renewable Resource Management* project, the MNES has submitted a proposal for an additional line of credit for private sector windfarms. The proposal envisages financing 115 MW of private sector windfarms at a cost of US$ 165 million. The MNES has proposed the financing of this project through:

- GEF grant of US$ 25 million;
- International Development Agency (World Bank) loan of US$ 30 million;
- Bilateral co-financing of US$ 50 million;
- IREDA financing of US$ 20 million; and
- Private sector contribution of US$ 40 million.

Another major development has been the interest shown by several foreign corporations in entering into joint ventures with Indian companies for setting up windfarms and manufacturing the equipment. Large US companies such as Zond, Carter, Cannon, etc., have already signed memoranda of understanding for the purpose.

Small hydro power generation

In India the small scale power generation through hydro resources is categorized as micro hydro for projects with installed capacity of up to 100 kW, mini hydro up to 2 MW and small hydro up to 15 MW capacity.[3] In the mid-1970s, the CEA (Central Electricity Authority) had estimated a potential of about 5000 MW for projects of up to 5 MW capacity in India. In the mid-1980s, the need for fresh estimates was widely recognized and a systematic reevaluation was initiated by the CEA in 1988–89. Preliminary results from just 9 states indicated a potential of 4037 MW spread over 889 sites with installation capacities ranging from 100–1500 kW. Furthermore, additional sites for nearly 1130 MW have already been identified requiring an investment of over Rs 24 000 million (US$ 800 million). Now the rough estimates of MNES place the potential at 10 000 MW.

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[2] The original target for the Eighth Plan, as formulated in late 1991, was 100 MW. Based on the experience of existing windfarms, increased commitment of the current government and availability of funds from multilateral agencies, the target was revised upwards. *See* MNES, 1993, *Overview of programs*, Ministry of Non-conventional Energy Sources (MNES), Government of India, June.

In order to provide a sharper focus to this renewable source of energy, the responsibility of small hydro development with up to 3 MW capacity was transferred in February 1989 from the Department of Power to the MNES. In the institutional structure now in place, the IREDA is primarily a source of loan assistance either from the funds allocated by the Indian government or external financial sources. The main current source of funds for small hydel development is the US$ 70 million made available to the IREDA through a World Bank loan for disbursement for setting up of irrigation canal/dam-based small hydro projects of up to 15 MW capacity. A separate project to prepare a master plan for development of small hydro power in the hilly regions has been launched with a funding of US$ 7.5 million from UNDP/GEF.

By now, about 113 MW (spread over 172 projects) had been commissioned and work is in progress at 173 sites to establish an additional capacity of 216 MW. Thus, the Eighth Plan target of 600 MW by 1997 is well in sight.

Solar thermal power generation

While attempts have been made globally to develop solar thermal power generating systems, efforts in this direction in India are relatively recent. For solar thermal power generation, the international technology development efforts can be grouped into four generic technologies, namely (i) solar central receiver systems, (ii) solar pond power plants, (iii) solar dish-stirling systems, and (iv) distributed linear parabolic collector systems with fossil fuel backup.

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[3] The categorization is fairly fluid not only between different countries, but even within a country at different times. For instance, up to 1982 China classified installed capacity below 12 MW and unit capacity below 6 MW as small hydro but subsequently increased the limit to 25 MW. *In this paper small hydro refers collectively to micro, mini, and small hydro up to 3 MW capacity.* Currently, there is a proposal to bring even the range of 3–15 MW under the purview of MNES.

The distributed linear parabolic collector system with natural gas backup (widely known as the Luz system) has received particular attention as it came closest to commercialization. Since its development in early 1980, Luz successfully developed, constructed and arranged finances for nine solar thermal electric energy plants. The plants are located in the Mojave Desert and supply Southern California with 354 MW of installed capacity. The first two plants (14 MW and 30 MW) were built in 1984 and 1985 and produced electricity at a cost of 24 cents/kWh. The next five were 30 MW plants built in the years 1986–88 which produced electricity at 12 cents/kWh. The two 80 MW plants built in 1989 and 1990 produced electricity at 8 cents/kWh. The next generation of Luz solar plants, to be constructed in 1995, are projected to produce electricity at a cost of approximately 6 to 6.5 cents/kWh.[4]

In India, the MNES has submitted a proposal for a 35 MW gross Luz type solar thermal power generation for GEF and World Bank financing.[5] To be sited at Maithania, Rajasthan, the project proposes to use oil-fired backup instead of natural gas and is expected to cost US$ 100 million.[6] A detailed project report for the proposed facility has been prepared by BHEL (Bharat Heavy Electricals Limited), which is also expected to execute the project.

Biomass power generation

Biomass for power generation has been recognized as an important component of the renewable energy program in India and this is reflected in the priority attached to it by the MNES. Biomass collection logistics and competing uses of biomass are the two most serious constraints in the widespread utilization of this resource for power generation.

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[4] In spite of the remarkable cost reduction achieved with this technology, Luz went bankrupt due to decreasing avoided costs of generation at which utilities were required to buy electricity. For a more complete discussion, see Newton D. Becker. The demise of Luz: a case study, *Solar Today* 6(1):24–27.

[5] The license for the Luz technology is reportedly now with M/s Solel, the Israeli subsidiary of a Belgian holding company.

[6] MNES has asked for a GEF grant of US$ 30 million. The Central government is to provide a grant of US$ 10 million and will be matched by the state government. Attempt is being made to obtain $ 50 million co-financing from multilateral (like IDA) and bilateral (German government) sources.

Nevertheless, there are niches with substantial potential for use of biomass for power generation. Three specific niches have been identified:[7]

- Bagasse cogeneration in sugar mills;
- Biomass waste from agricultural operations or agro-industries in concentrated geographical pockets where power generation can be undertaken using steam Rankine cycle-based power plants; and
- Geographical pockets where the biomass availability is limited (not sufficient to support combustion-based power generation which warrants higher capacities and consequently larger quantities of biomass to be economically viable) and where biomass gasifiers (of about 500 kW) would be cost-effective.

Bagasse-based cogeneration

In terms of relative detailed strategy for biomass-based power generation, the MNES is far ahead with its plans for bagasse-based cogeneration in comparison to the other two options. A Task Force constituted by the MNES estimated the potential for surplus power generation at 3500 MW in 420 sugar mills in India. The Task Force identified financial constraints as the primary hurdle in the penetration of cogeneration technology in sugar mills. High capital investment, almost as much as the investment for setting up the sugar mill itself, is required to set up efficient cogeneration facilities. High interest rates and the low repaying capabilities of the sugar manufacturing sector are believed to be the main constraints in the modernization of the old plants and setting up of efficient cogeneration facilities.

Institutional structure for power generation is another serious constraint. In general, SEBs (State Electricity Boards) have shown little interest in encouraging the sugar factories to cogenerate surplus power. It is believed that some legislation similar to the PURPA (Public Utility Regulatory Policy Act) of the USA, which makes it mandatory for the utility to buy energy generated by the cogenerators at reasonable rates, would encourage increased cogeneration. Some states in India have encouraged cogeneration: for instance, Karnataka allows banking and wheeling of electricity by surplus producers. The surplus power generated can be 'deposited' with the SEBs and drawn within the year either for use or for a unit of the group. It also allows wheeling of power through the grid to another industry of its choice and sale at a mutually agreed price after deducting a specified percentage of the energy wheeled. Recently Tamil Nadu and Maharashtra, which are important sugar producing states, have started examining the possibility of buying the energy from sugar factories.

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[7] See Project Brief, *Project on Biomass Power*, submitted to the Global Environment Facility, by the MNES, September 1994.

The key to a successful bagasse cogeneration program would be the penetration of high pressure boilers in the sugar mills. Most Indian sugar factories use low or medium pressure boilers. It is believed that high pressure boilers would make cogeneration efficient and much more attractive for the units opting for cogeneration.[8] The high pressure boilers are, however, new to the sugar industry, increase the perceived risks, and result in higher costs. Most sugar factories in public and cooperative sectors are small scale and there is a shortage of the sound technical management required to maintain this type of boiler.

Under the program for promotion of bagasse-based cogeneration, the MNES provides a capital subsidy of 30% of total equipment cost subject to a maximum amount of Rs 7 million/MW of surplus power using state-of-the-art technology[9] to generate a minimum of 5 MW of surplus power. For those projects which use relatively more established technology for steam generation, soft loans are available under the Sugar Development Fund of the Ministry of Food for production of 4 MW or more surplus power, for modernization. Several international organizations have also worked out joint ventures to enter this sector.

Biomass gasifiers for power generation

The gasifier program in India was launched in 1986 by the MNES with a 3.7 kW gasifier based on wood gasification of which over a thousand systems have been installed to date. The gasifiers were promoted for irrigation with the objective of reducing the use of diesel. One evaluation,[10] covering approximately 20% of the gasifiers installed by 14 nodal agencies in India, found that a little under 45% of the systems were in use with just 14% being used in the dual-fuel mode. Over 25% of the gasifiers were either used intermittently (about 7%) or not used at all with the gasifier being a probable means of obtaining a diesel pumpset at a lower cost than the market (18%). Nearly 57% were never used after commissioning while a little under 5% were never commissioned even though the gasifier had been delivered at the site of installation. Even for the working gasifiers, the field-level performance has not been very well documented. Evaluation of the relevance and the reliability of the gasifier technology, now considered to be nearing commercialization, is therefore difficult. An evaluation of 67 installed systems, which had together clocked 17 500 hours (average of 290 hours/year each) reported that two systems had failed completely and four systems had more than 1000 hours of trouble-free operation. It is, therefore, difficult to gauge the reliability of a technology on the basis of such limited operational data.

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[8] Maximum surplus power for export can be generated by employing high pressure boilers, high-efficient turbogenerators and combustion systems and pre-dried bagasse. A typical 2500 tcd (tonnes crushed per day) sugar mill employing a 22 ata (absolute atmospheres or kg/cm^2) pressure boiler at 330 °C will generate 64 TPH (tonnes per hour) of steam and 2.5 MW of electricity (typical in-house requirement of the mill). If the mill were to use efficient equipment (such as hydraulic drives and electric motors) *and* use a medium pressure boiler (45 ata and 480 °C), a surplus of 4–5 MW of power for export to the grid would be possible. With a high pressure boiler (65 ata and 480 °C), the surplus power would be 7 MW. See *India: Greenhouse gas pollution prevention project*, Project Brief, Annex B, GEF FY94 USA Parallel Cofinancing- Seventh Tranche, USAID; and MNES, 1993, *Report of the Task Force for Formulation of a National Program on Biomass Based Cogeneration in India*, Ministry of Non-conventional Energy Sources, October.

[9] While it is not clear what criteria would be used to determine the 'state-of-the-art' technology, there are indications that the boiler would need to operate at 80 ata and 510 °C.

The main problems with the small (5 hp) gasifier irrigation system program have been:

- The nature and the quantum of the subsidy. At the current subsidy level the cost of the gasifier coupled to the diesel pumpset was less than the cost of the diesel system itself. The distorted price made it impossible to determine the level of acceptance of the technology among users, and in many cases it was noticed that the gasifier had been decoupled with the diesel engine in use.
- The reliance on wood gasification systems when there is an endemic shortage of wood has restricted the use of the gasifier.

The use of the small gasifier for irrigation (less than 150 days in a year) is not techno-economically viable.

The general problem related to the gasifier program has been the inherent material problem related to the thermal cycles. Due to this gasifiers have commonly failed after 500 hours of operation.

These constraints have been recognized by the researchers as well as the MNES and more emphasis is now being placed on multifuel gasifiers in the capacity range of 50–500 kW. The program has also set a goal of 2000 hours of system operation without any failure.

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[10] Subramanya N S, Prabhakar Rao K V, and Ramprasad M S, 1993. Development of strategies for effective dissemination of gasifier/stirling engines, In: Paul P J and H S Mukunda (eds), *Recent advances in biomass gasification and combustion: Proceedings of Fourth National Meet on Biomass Gasification and Combustion, 6–8 January, 1993*, Interline Publishers, Bangalore, pp. 319–333.

Gasifier technology development efforts in India are still directed at overcoming material problems and producing clean gas. Thus the gasifier program is essentially at the research and development stage, and a reliable and cost-effective technology needs to be developed prior to working out strategies for large scale dissemination.

Solar photovoltaics

Solar photovoltaics is another exciting technology which has vast scope for application in India. There are about 100 000 villages still to be electrified and over 70 million households needing electricity connections, most of them in remote areas where it is costly to extend the conventional grid, and photovoltaics offer a good alternative. In this background, India today is on the verge of implementing one of the largest photovoltaic programs in the world. Among the highlights of this ambitious program of the MNES are the supply of one million solar lanterns and 50 000 solar pumps. About 100 000 villages will be provided with solar-powered radio telephone systems. With over 25 companies actively engaged in the manufacture of photovoltaics, India has the indigenous capability to produce all the components; everything from high purity silicon to complete photovoltaic systems.

Programs have also been initiated to use renewable energy technologies for meeting the needs of important sectors such as telecommunications, railways and urban development, which offer an attractive market for photovoltaics.

Conclusion

There is strong reason to be optimistic about the likely role that renewable energy sources will play in the energy sector in India. The demonstration of reliability under field conditions by some technologies, changes in the institutions involved with the renewable energy sector, a shift in emphasis from direct subsidies to fiscal incentives and funds for concessional financing of investments are among the important reasons. Obviously, much more needs to be done. The emphasis of the MNES should be on creating a demand--pull and avoiding a technology-push. The visualized scale of use of RETs cannot be fulfilled without a market-driven demand which, in turn, requires involvement of the industry. It appears desirable for the MNES to continue in its role of a facilitator of rapid commercialization. For this, it is important to coordinate field-testing and demonstration on a reasonable scale. At the same time, the distinction between the demonstration phase and the beginning of commercialization should be unambiguous. Information dissemination, including the use of commercial media to promote a demand-pull, should form a part of the mandate for the MNES.

Similarly, innovation in financing and developing fiscal incentives needs to continue and the anomalies removed. It will be important for the MNES to respond quickly and judiciously if substantially greater investment by the users in general and the private sector industries in particular is to take place.

While it is important for the MNES to loosen control on the renewable energy programs and to encourage private sector investment, its continued involvement would be imperative in the rural energy sector. Energy demand in the rural areas of India is still dominated by subsistence requirements which are largely met by biofuels. A major part of the supply system is not influenced by the market system and the transactions are rarely monetized. For this section of the population, there are few options, particularly in the conventional market-based framework, to alter the rapidly deteriorating biomass resource base due to the inherent characteristics of the rural energy systems. There is also a certain sense of urgency since the deteriorating biomass base will effect subsistence needs of a section of the population with little or no influence or economic ability in the existing structure. While a top-down, centralized government initiative cannot be the solution to the rural energy problems, pragmatism would suggest a continued and possibly, a greater involvement in designing and implementing rural energy interventions. Till viable institutions at the local level emerge with alternative programs to replace and/or make the government-sponsored ones superfluous, there is a need to involve as many local institutions, including non-governmental organizations and private entrepreneurs, as possible with the existing efforts.[11] Increased local-level participation of any kind has substantial payback as the qualitative enhancement in the biogas programs in many districts of Gujarat, Maharashtra, Andhra Pradesh, and Karnataka, with the involvement of private entrepreneurs as turnkey operators, would indicate.

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[11] Sinha C S, Venkata Ramana P and Joshi V, 1994. Rural Energy Planning in India: designing effective intervention strategies, *Energy Policy*, 22(5):403–414 .

Renewable electricity in India: progress, promotion, and policy

Ajit K Gupta

The GOI (Government of India) attaches significant importance to the development and promotion of renewable energy. India is perhaps one of the few countries in the world to have drawn up a comprehensive strategy and action plan and set specific goals for renewable energy-based capacity addition in the energy sector of the country. It is perhaps the only country in the world which has established a full-fledged MNES (Ministry of Non-conventional Energy Sources), under the overall charge of the Prime Minister. It is recognized that increased use of renewable energy is essential not only for sustainable growth in the long term, but also for ensuring equitable distribution of the benefits of growth. Greater deployment of renewable energy sources is becoming a more acceptable alternative and public opinion seems to be gathering momentum in its favor. These sources offer several benefits which can relieve much of the pressure threatening sustainability.

The GOI started a modest program for the development of renewable energy technologies in the mid-1970s in the wake of the 'energy crisis' of 1973. As a follow-up to the 1981 UN Conference on New and Renewable Sources of Energy, which underscored the need for drawing up plans for achieving a harmonious transition from an economy based on hydrocarbons to one based on renewable energy resources, a high-powered CASE (Commission for Additional Sources of Energy) was constituted. A separate Department was also created under the Ministry of Energy, at par with the Departments of Coal and Power, to provide focused attention to this sector. In 1992, the government decided to give a further boost to increase the deployment of near or already commercial renewable energy technologies by upgrading the Department to a full-fledged Ministry.

New strategy and action plan

Under the Strategy and Action Plan of 1993, the MNES is consolidating and strengthening technology development and commercialization by providing market orientation and creating a favorable policy environment. The goals have been redefined, and now aim at generating 2000 MW of power from renewables by 1997. Attractive opportunities are being created and procedural formalities simplified to foster private investments. A key element of the new strategy for commercialization is to utilize the government's limited budgetary resources to demonstrate the technical and economic viability of 'emerging' technologies and applications, with a view to leverage institutional finance and private investments, and attract external assistance. The encouragement of entrepreneurship and greater competition is expected to reduce costs, improve the quality of equipment, and lead to the establishment of a large number of market outlets, a service network, and repair and maintenance infrastructure.

Power from renewables

Renewable energy is expected to create maximum impact in the production of electricity. Projections indicate that by the end of the decade, it would be cost-effective to generate and supply renewable electricity of up to several thousand megawatts, as its efficiency is increasing and costs are decreasing, while the costs of conventional electricity are increasing. Besides grid supply augmentation, renewable electric technologies offer possibilities of distributed generation at or near the points of use, which can reduce peaking loads and save on costly upgradation and maintenance of transmission and distribution networks to serve the growing demand. The new Strategy and Action Plan has accordingly given special emphasis to the generation of grid quality power from renewables, including wind, small hydro, biomass-based, and solar powers.

India is implementing the world's largest wind resources assessment effort covering over 600 stations in 25 states. A wind power capacity of 180 MW has been installed, which has placed us among the top five countries in the world. A capacity of over 1500 MW is being developed and the goal of 500 MW capacity by 1997 is expected to be achieved. The total turnover of the wind industry is likely to exceed US$ 200 million during the current fiscal year. According to a recent report of the consulting firm, Arthur D Little, India is ahead of other countries (except USA) in projections for creation of wind power capacity of the order of 750–1200 MW by the turn of the century.

Small hydro power development of up to 3 MW capacity on canal drops, dam toe and run-of-river sites is another area with considerable potential. A capacity of 114 MW has been commissioned, and projects aggregating up to 220 MW are under construction. Offers for over 350 MW have been received by the states from the private sector. The goal for capacity addition is 600 MW by 1997. Decentralized generation and distribution in the hilly regions, with full involvement of local communities and NGOs, is gaining attention. A UNDP/GEF (Global Environment Facility) Hilly Hydro Project and a portable sets scheme have recently been taken up.

India generates a vast amount of biomass material which can be utilized for power generation. An important program has been launched on bagasse cogeneration aimed at optimizing surplus power generation through upgradation of boiler pressures and improving efficiencies. The first major project which will generate 9 MW surplus power, is nearing completion. Three projects of 26 MW capacity have recently been cleared, and projects aggregating up to 225 MW are being firmed up. A USAID/GEF project has been approved for off-season alternative biomass cogeneration. The goal for 1997 is 300 MW. Programs are also being developed for direct combustion and grid-interactive gasification using woody biomass or agricultural residues such as crop straws, stalk, and husk.

In the area of solar power, both solar thermal as well as solar-photovoltaic routes are being studied, with a view to establish a sound technology base and manufacturing capacity, and to provide operational experience to utilities and industrial users. A 35 MW solar thermal power project based on line focusing parabolic trough collectors is proposed to be taken up during the Eighth Five-Year Plan (1992–97). Two 100 kW partially grid-connected solar-photovoltaic projects for village electrification are also nearing completion. There is considerable interest among manufacturers and developers to take up grid-connected photovoltaic projects.

Rural electrification through solar photovoltaics

Even though 85% of the villages in India are deemed to have been electrified, only about 28% of rural households use electricity. About 86 000 villages are yet to be electrified, of which at least 20 000 may have to forever remain outside the ambit of electrification. Seventy-one million rural households still do not use electricity. Renewable electric technologies, in particular solar photovoltaics, are eminently suited for electrification of these villages.

A broad-based program has been undertaken to develop and promote solar-photovoltaic technologies. A total of over 150 000 systems aggregating to over 11 MW have so far been installed. This comprises a capacity of 5 MW for lighting and water pumping in rural areas; about 5 MW for rural telecommunication; and 1 MW for other applications. The main focus of the program has been on decentralized energy supply. Over 75 000 street lights, domestic lights including solar lanterns, community lighting systems, and water pumps have been installed, besides 119 village-level power plants. We have set a goal for 1997 of 400 000 solar lanterns, 5000 solar pumps, and 400 village-level power plants. Off-grid solar-photovoltaic systems up to 2 kW have been found to be competitive between 5 and 10 km from the grid and can, therefore, serve 'niche' markets for solar home systems, completely offsetting grid-extension or at least postponing it.

India today manufactures everything from high purity silicon to complete photovoltaic systems. The solar cell and module production projections for the current year are 5.5 MW and 7 MW respectively, and the total turnover of the industry is likely to cross US$ 70 million. A number of joint ventures are emerging with leading companies in the world for the establishment of production facilities based on the latest technologies, as well as for project development. National standards are being developed, and a National Photovoltaic Test Facility has been established with USAID assistance at the Solar Energy Centre with the objective of improving the quality of cells, modules, and systems. The immediate impact of the market forces has been a drop in module costs by 25% to about US$ 5.2 per peak watt, and better accountability of the manufacturers towards installation, repair, quality, etc.

Other thrust areas

Another 'niche' for renewable energy technologies is demand-side applications in urban centres and industry, such as air and water heating, process heating, and space heating and cooling. Water heating systems are now in common use in commercial and industrial establishments, and are becoming popular for domestic use as well. Over 300 000 m^2 of collector area has already been installed. The goal for 1997 is 1.1 million m^2 collector area. Over 100 manufacturers and entrepreneurs are engaged in the manufacture and installation of these systems. Sophisticated testing facilities have been established at the Solar Energy Centre and six other centres in different parts of the country.

In the area of cooking energy, the programs for biogas plants and improved woodstoves are sought to be universalized. Around 2 million biogas plants and 17 million improved woodstoves are at present in use. Under the

Draught Animal Power Program, new designs of improved bullock carts are being promoted, and modern animal-drawn devices introduced for use in agriculture and village industry.

Energy recovery from urban, municipal, and industrial wastes is being promoted, both from the view of energy generation as well as minimizing pollution. A UNDP/GEF project on high-rate biomethanation systems is being implemented to initially cover community sewage, leather industry/abattoirs, pulp and paper, and vegetable market wastes.

Programs are also being developed for new technologies which appear promising over a longer horizon, such as ocean thermal energy conversion, tidal power, fuel cells, electric vehicles, and alternative fuels for transportation.

Promotion policy

The role of the government is to act as a 'mission' leader and facilitator, and to focus on policy, legislation, testing and standards, training, information dissemination, and education. Private enterprise and initiative is being encouraged by supporting assessment of potential and needs, research and development, and demonstration, as well as helping industry to develop and commercialize new technologies. Promotional and fiscal incentives are being provided to create the necessary 'market pull' or short-term demand that will lead to expansion of the industry and subsequent reduction in costs.

Incentives

The incentives available include tax concessions such as accelerated depreciation, tax holidays for power generation projects, soft loans, customs and excise duty reliefs, liberalized foreign investment procedures, etc. The import and excise duty regimes are constantly being reviewed to allow induction, development and deployment of the latest technologies, and provide for healthy competition. Major initiatives have been taken in the recent past to create remunerative and assured markets for non-conventional energy-based power generation. Guidelines have been sent to all the states on general policies and facilities for wheeling/banking/purchase of power from such projects. It has been proposed that the states may consider purchasing such power at a minimum rate of Rs 2.25/kWh (around 7.5 ¢/kWh). Supplementary guidelines have now been circulated, which provide for annual escalation at the rate of 5% and suggestions have been made for security of payments for the power sold. It is hoped that this will lead to attractive and assured returns on investments by developers and investors (see Annexure I).

In accordance with the guidelines circulated to state governments, ten states have come forward and announced attractive policies for private sector power projects based on non-conventional energy sources including wind power, small hydro power, and cogeneration. In addition to suggestions for wheeling, banking and third party sale, the Punjab, Madhya Pradesh, Himachal Pradesh, Kerala, and Andhra Pradesh governments have agreed to the proposed buy-back rate of Rs 2.25/unit. The Tamil Nadu government has enhanced the buy-back rate for wind power to Rs 2/unit, while for cogeneration, it has agreed to the prevailing high transmission rate. Uttar Pradesh has also announced a buy-back rate of Rs 1.75/unit for wind and small hydro power; for cogeneration, it has agreed to Rs 2.25/unit, or a rate which allows 16% return, whichever is lower. In Gujarat, a buy-back rate of Rs 1.75/unit is being offered along with an attractive sales tax incentive. The sales tax incentive is also available in Madhya Pradesh. The Maharashtra government has agreed to a rate of Rs 2.25/unit and will provide equity support through MSEB (Maharashtra State Electricity Board) for bagasse-based cogeneration projects taken up by cooperative sugar factories; the policy for wind power is being finalized. Karnataka has announced a rate of Rs 1.75/unit; in addition, for cogeneration projects they have announced a capital subsidy. The West Bengal and Assam governments are finalizing their policies.

The state governments have been requested to create a separate empowered institutional entity for non-conventional energy projects, particularly, for power generation. Several states such as Karnataka and Andhra Pradesh have already set up a high-powered state level committee/single windows for clearance of private sector projects. The SEBs have been asked to create separate cells for non-conventional energy power projects.

IREDA financing

The IREDA (Indian Renewable Energy Development Agency Ltd.) was established in 1987 with the main objective of operating a revolving fund for development, promotion, and commercialization of renewable energy technologies by providing soft-term finance. It is serving as a model for other developing countries and has received considerable international assistance. It is operating a World Bank and GEF line of credit amounting to US$ 195 million to promote private sector wind power generation and canal-based small hydro projects aggregating up to 185 MW, and includes assistance of US$ 55 million to be used as a revolving fund for marketing of solar-photovoltaic systems aggregating to 2.5 MW. Innovative marketing and financing mechanisms including credit and leasing are being developed with the involvement of manufacturers, intermediaries, and the users themselves. Another scheme for solar pumps is being operated through the IREDA with an innovative subsidy-cum-marketing and financing arrangement. A line of credit amounting to US$ 100 million from ADB (Asian Development Bank) is under finalization for bagasse-based cogeneration, solar thermal systems, biomethanation, and wind energy.

Policy issues

The average cost of generation from certain renewable energy technologies, which varies from Rs 1.75–2.5/kWh (6–8 ¢/kWh), already compares quite favorably with those for new thermal power projects located away from coal mining areas, or for captive diesel generation. Their costs will decline further through higher efficiency and reliability obtained from advances in technology, and larger scale and more efficient manufacturing processes. They will turn out to be even more competitive, if all the direct/indirect subsidies, external social and environment costs are taken into account for conventional power. These costs are roughly equal to the commercial cost for conventional electricity, so that its total cost to society is actually double the commercial cost.

In order to accelerate commercialization and the development of a stable non-conventional energy industry and sustained growth of utilization, it is necessary to create a level playing field in the energy sector. To begin with, rationalization of energy pricing and tax policies should be undertaken, particularly tariff for power supply to the agricultural sector and distortions through government subsidies removed, which favor fossil fuels. The true and full costs should be considered in the economic evaluation of various options to promote fair competition. The levy of a 'cess' on fossil fuel-based electricity from industrial and commercial consumers, and/or the levy of a 'carbon tax' or 'pollution tax' on new fossil fuel-based power plants, are a few measures for the promotion of renewable energy-based power generation.

The utilities should undertake Integrated Resource Planning, or least-cost planning, to consider the broadest possible range of both supply and demand-side options, including renewables. In fact, a specific portion of all new power generation capacity could be reserved or set aside for renewable energy power projects, or all new conventional power projects required to include suitable renewable power blocks in their projects.

The present imbalances in resource allocations will need to be corrected and adequate funds provided in the Central and State Plans, as non-conventional energy sources not only contribute to power development and rural development, but pervade almost all other sectors of socioeconomic development.

Legislation

In keeping with the government's thrust to encourage privatization in the power sector, the legislation governing the electricity sector, namely, the Indian Electricity Act, 1910 and the Electricity (Supply) Act, 1948 have been amended in October, 1991 to enable private sector companies to undertake distribution as licensees or to establish power generating capacity. The private sector can also set up non-conventional energy-based power projects of any size. Besides being able to generate power from decentralized sources, they should be allowed to distribute it freely either by using the existing network, or by expanding the network on their own, for sale either to the SEB, third-party bulk consumers or to the local community.

Purchase of non-conventional energy-based power by the SEBs should be made mandatory, and the rates of purchase should be just, reasonable, and fixed using the 'avoided cost' principle, according to which the purchase price should exceed the cost to the SEB of energy that the Board would generate from new capacity additions or would purchase from another source. The rate and Power Purchase Agreement should suit the capital-intensive, low-operating cost non-conventional energy projects. Wheeling and banking of energy should become mandatory, keeping in view the site-specific, seasonal/intermittent nature of non-conventional energy sources.

Future directions

The total annual turnover in terms of goods and services of the renewable energy sector in India has already reached about Rs 1500 crore (about half a billion US dollars). It has attracted some of the biggest names in the industry, and developers and investors from India and abroad. Further inflow of technology, capital, international assistance, marketing, and managerial expertise, in the framework of a favorable policy environment will help to create more employment opportunities, establish local production and expand the markets.

The new Strategy and Action Plan being envisaged by the Ministry seeks to remove barriers to private initiative and participation, and to create healthy market conditions. However, in order to take a long-term view, and to realize the full potential of renewables, the government plans to formulate a comprehensive renewable energy policy, which will encompass the government, industry, research institutions, non-governmental organizations, communities, and users. The policy will help to create awareness, foster development and demonstration, accelerate commercialization, and create an effective support infrastructure and delivery mechanism for installation, operation, maintenance, and repair. The government also plans to introduce special legislation to promote renewables, as the present legislation governing the electricity sector is considered inadequate for effective and rapid development of the renewable energy sector.

Setting broad goals in a 15-year Perspective Plan will accelerate commercialization and help in the development of a stable industry and its sustained growth. The resource, technology, and commercialization prospects will have to be evaluated to determine the level of deployment in each case, so that capacity additions are by and large techno-economically viable. Short-, medium- and long-term national goals will then have to be fixed for non-conventional energy-based projects, both grid-connected as well as decentralized.

If a goal of 10 GW renewable electric capacity is set for the year 2010, this would amount to a 5% share in the total anticipated installed capacity of the country, and involve investments of nearly US$ 15 billion. It is within such a perspective that plans and policies need to be developed, and action initiated towards realization of goals.

Annexure I

Guidelines for promotional and fiscal incentives by state governments for power generation from non-conventional energy sources

Operative period

The scheme of promotional and fiscal incentives will come into operation with immediate effect and remain in force for a period of five years.

Eligible producers

For those generating electricity and feeding in full or part to the State Grid from non-conventional energy sources such as wind electric generators, small hydro plants, biomass combustion, cogeneration, etc., there will be no restriction on generation capacity or supply of electricity to the grid. Consortia or cooperatives will also be eligible.

Grid interfacing

- Interfacing, including transformers, panels, kiosks, protection, metering, HT (high tension) lines from the points of generation to the Board's nearest HT lines, etc., as well as maintenance will be undertaken by the producer as per the specifications and requirements of the Board, for which he will bear the entire cost. Alternatively, these works and their maintenance could be undertaken by the Board, at charges to be decided by the Board.
- Depending upon the generation capacity, if the substation capacity at 33/11 kV or higher levels is required to be augmented, or 66 kV or higher capacity transmission lines are to be provided, this will be undertaken by the Board, at their cost.
- Two separate meters, one for the export of power to the grid, and another for import from the grid, will be installed on the HT side by the producer. The meters and metering boxes will be sealed by the Board.
- Necessary current limiting devices such as thyristors will be installed in

the generating equipment by the producer. Capacitors of sufficient rating will also be provided in the equipment to ensure that the power factor is always maintained above 0.8.

Facilities by the SEB (State Electricity Board)

1. *Wheeling.* The SEB will undertake to transmit on its grid the power generated, and make it available to the producer for captive use or to a third party within the state, at a uniform wheeling charge of 2% of the energy fee to the grid, irrespective of the distance from the generating station. The third party must be an HT consumer of the Board, unless this stipulation is relaxed specifically by the SEB.
2. *Banking.* The SEB will permit the electricity generated to be banked for a period of up to one year.
3. *Sale of power.* The SEB will purchase electricity offered by the producer at a minimum rate of Rs 2.25/unit, with no restriction on the time or quantum of electricity supplied for sale. This rate will be reviewed every year, and will be linked to standard criteria such as the wholesale price index. The producer will also have the option to sell the electricity generated by him to a third party within the state (as defined above), at a rate to be mutually settled between them.
4. All transactions between the Board and the producer involving wheeling, banking or sale of power will be settled on a monthly basis.
5. *Exemption from duty.* Consumption of electricity generated by the producer will be exempted from electricity duty.
6. *Exemption from demand cut.* An exemption from demand cut to the extent of 30% of the installed capacity of the producer will be given by the Board.

Other incentives

1. Sales tax benefits will be available to the producer, who owns the project (Resolution of the Government of Gujarat dated 27 January 1993 is enclosed for guidance).
2. The producer will be allowed to use the water for power generation. Royalty on the water used for small hydro projects will be charged at a rate not exceeding 10% of the prevailing electricity tariff for HT consumers.
3. Power generation from non-conventional energy sources will be treated like any other industry, and incentives normally available to new industrial units can be availed.
4. Concessions given to industrial units in backward areas will be provided, such as exemption from taxes and duties, capital subsidies, etc.

5. Infrastructural facilities such as approach roads, water supply, crane, power during construction period, etc., will be provided on the lines of industrial estates.

Application and clearances

1. Producers should submit their application for setting up the project and for grid interface in the Proforma to the State Nodal Agency/State Electricity Board (a simple composite application form should be devised which will include all statutory approvals such as that of the Chief Electrical Inspector, etc.)
2. Clearance will be provided within a period of two months from the date of application.
3. An agreement will be entered into with the producer within a period of one month from the date the clearance is provided.
4. If the applicant does not take effective steps (i.e. at least 10% of the total project cost should be incurred) to implement the project within six months from the date of obtaining possession of land, the Agreement could be terminated and the site allotted to another applicant. If, on the other hand, land is not provided within three months from the date of Agreement, the applicant will have the option to terminate the Agreement.

Guidelines for the fixation of purchase price for power produced from non-conventional energy

1. The SEB (State Electricity Board) will announce a base purchase price every year for the electrical energy purchased by it from non-conventional energy-based power projects. These rates shall be valid from 1 April to 31 March of the following year. The base electrical energy purchase price valid for 1994–95 shall be a minimum of Rs 2.25/kWh and shall be escalated at a minimum rate of 5% every year. Announcement of revised base prices shall be made by the SEB on 1 April every year. The base price shall be applicable to all non-conventional energy-based power projects such as solar, wind, small hydro, biomass, etc., for which PPAs (Power Purchase Agreements) are signed during a year.
2. A promoter/developer shall be entitled to receive the base price set out in the PPA for all electrical energy delivered from his project to the state grid for the duration of the PPA. The rate shall be equal to base price in the year of signing the PPA, escalated at a rate of 5% per year for a period of 10 years, from the date of signing of the PPA. From the end of the

tenth year, and for the remaining duration of the PPA, the new purchase price shall be equal to the purchase price at the end of the tenth year, or the HT (high tension) tariff prevalent in the state at that time, whichever is higher.

3. A monthly invoice shall be submitted by the promoter/developer to the SEB at its designated offices, for the net electricity supplied by him to the Board. The Board shall make payment of amounts due, calculated at the purchase price for that particular year, within a period of 30 days. The Board shall also provide facilities of an escrow account or an irrevocable, transferable, divisible and confirmed standby letter-of-credit issued by State Bank of India, or another nationalized bank, acceptable to the promoter/developer. The amount of the letter-of-credit shall be equal to the expected total of two years payment by the Board. To ensure prompt realization of the dues, and in order to provide a security cover, the Board shall issue 'Electricity Credit Notes' to the promoter/developer equivalent to the amount of electricity received by the Board, whenever it is unable to pay in cash within the stipulated period. The Electricity Credit Notes shall be transferable to one or more consumers of the Board, who will be allowed to adjust the amount for which the Credit Notes have been issued, from their electricity bills due to the Board. The validity of Credit Notes shall be six months.
4. The duration of the PPA shall be a minimum of 20 years, which could be extended by another 10 years, through mutual agreement.

Policy environment for commercialization of renewable energy technologies in India

Chandra Shekhar Sinha, Venkata Ramana P

Since 1992, commercialization of renewable energy technologies has been receiving increasing emphasis within the MNES (Ministry of Non-conventional Energy Sources). This has resulted in a perceptible shift in the renewable energy implementation strategies. Several renewable energy programs have changed from being government-driven to relying more on the market through encouraging the involvement of the private sector by loosening controls and being more responsive. This is reflected in the strengthening of fiscal incentives, and the attempts to phase out financial subsidies and reduce emphasis on government-funded demonstration programs. Success has been particularly noticeable in renewable energy programs for power generation. The process has been helped by wide-ranging changes in the power sector of the country.

It is, however, important to recognize certain institutional limitations which will determine the speed by which changes are possible in the power sector. Electricity is listed as a concurrent subject in the Constitution of India. The implication is that the final decision to approve any private[1] sector project is within the jurisdiction of the state government in which the project is located or proposed to be located. Furthermore, all commercial aspects, including Power Purchase Agreement, level of tariffs and related issues are also within the jurisdiction of the concerned SEB (State Electricity Board) and/or state government. While a number of state governments have responded with innovative policies to complement the national effort in reforming the power sector, the extent to which the Central Government regulations can result in the implementation of policies will be determined by the decisions of individual states and their electricity boards.

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[1] For Central public sector power projects, the approval is required by the competent government. Amendment of section 2 of the Electricity (Supply) Act, 1948 through Notification SO 702(E), dated 15 October 1991 states that the 'Competent Government' means 'the Central Government in respect of a Generating Company wholly or partially owned by it...'..*see TIDE (TERI* Informa*tion Digest on Energy),* 4(2) (June 1994): 215–249 for extracts of amendments in the Electricity (Supply) Act, 1948 in the period 1991 to 1994.

This paper attempts to document some of the Central Government initiatives in the renewable energy sector. It also describes the innovative regulations formulated and implemented by several state governments. It is intended to supplement what has been documented elsewhere[2] and therefore focuses on three programs which have contributed significantly to the evolution of a renewable energy policy in India to date—wind, small hydro, and biomass cogeneration programs.

Reforms in the power sector of India

The power sector in India has undergone significant restructuring in the last five years.[3] As a result of the reforms, the private sector can now set up coal, gas, hydel, wind or solar projects of any capacity. Such private sector companies can be set up, without the concurrence of the Central Electricity Authority if the project cost is below Rs 250 million,[4] as enterprises to operate either as licensees or as generating companies with a debt–equity ratio of 4:1. A minimum of 11% of the total outlay is required as promoter's contribution and at least 60% of the total project cost must come from sources other than Indian public financial institutions. Hundred per cent equity participation is permitted for projects by foreign private investors. Fiscal incentives allowed to the private sector investors in the power sector includes:

- a five-year tax holiday on profits and gains of new projects for generation or generation and distribution of power;

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[2] Venkata Ramana P and Sinha C S, 1995. Renewable energy program in India, background paper for International Seminar on *Renewable Energy Development in India—Analysis of the US Policy Experience*, January 27–30; and Sinha C S, 1992. Renewable energy programs in India: A brief review; experience and prospects, *Natural Resources Forum* 16(4):305–314.

[3] For a much more comprehensive discussion of the reforms in the power sector to encourage private sector investments, see the special issue of *TIDE (TERI Information Digest on Energy)*, 4(2) (June 1994) on private sector power development.

[4] Till *Resolution No 7/8/88:thermal* (dated 22 October 1991) of the Department of Power, the limit was Rs 50 million. *See TIDE (TERI Information Digest on Energy)*, 4(2) (June 1994):222.

- faster depreciation on assets; and reduction in customs and excise duty on equipment.

These and other incentives, particularly the two-part tariff with guaranteed 16% return on equity for a minimum 68.5% plant load factor, has 'kick-started an entire industry'.[5] The government has received proposals for 75 projects, of which 35 are from foreign investors, aggregating a capacity of 32 662 MW and an investment of Rs 1041 billion.[6]

Incentives for wind power generation

The mainstay of the Central Government incentive for wind power generation is accelerated depreciation allowance: under the Income Tax Act,[7] the Government of India allows 100% depreciation in the first year of commissioning of the windfarm. Other elements of the incentives include soft loans through the IREDA (Indian Renewable Energy Development Agency), reduced customs duties on imported materials and equipment, and exemption from excise duty and central sales tax.

The IREDA's financing scheme for wind energy equipment

Under the Wind Energy Equipment Financing Scheme, proposals for windfarms up to 1 MW are eligible. The total loan amount permitted is 90% of the cost of equipment[8] at 14% interest[9] for a maximum period of eight years (including a one year moratorium). All other terms and conditions are similar to those for other schemes of the IREDA.[10]

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[5] Somers R. 1994. Policy adjustment now to support sustainable growth in India's power sector. *TIDE (TERI Information Digest on Energy)*, 4(2):103–108.

[6] Ramji N. 1994. Policy to encourage private investment in the Indian power sector—a perspective. *TIDE (TERI Information Digest on Energy)*, 4(2):93–101. See also details of foreign company collaborations in power generation in India, *TIDE (TERI Information Digest on Energy)*, 4(2):139–141.

[7] Through Section 32 Rule (5) Appendix-I of IT Act, 1961.

[8] List of equipments includes the wind electric generator (capacity range of 80–250 kW), tower, control panel and transformer. The IREDA reserves the right to put a ceiling on the permissible costs for the items.

[9] Loans secured against bank guarantees are eligible for a 0.5% rebate on interest rate.

[10] See IREDA, 1993, *Guidelines for loan assistance*, Indian Renewable Energy Development Agency (IREDA). For a summary table of the terms and conditions, see Venkata Ramana P and Sinha C S, 1995. Renewable energy program in India, background paper for International Seminar on *Renewable Energy Development in India—Analysis of the US Policy Experience*, January 27–30.

Incentives by state governments for wind power generation

Largely based on the success of innovative guidelines for wind energy power generation introduced by the TNEB (Tamil Nadu Electricity Board), the MNES has formulated guidelines on the implementation of windfarm development projects with private sector participation.[11] The main elements of these guidelines, to be implemented in Andhra Pradesh, Karnataka, Kerala, and Tamil Nadu in southern India and Gujarat in western India are:

- the state must have a policy in place which guarantees; (i) wheeling[12] of generated power at a rate of 2% for the whole state, and (ii) permits banking of the generated electricity for at least eight months in a year;
- the floor level buy-back rate of Rs 2/kWh of wind-generated electricity;
- third party sales of wind-generated electricity should be permitted at the usual wheeling rate of 2% through the state grid;
- wind generation facilities should be treated as industries, and all financial and fiscal incentives available to other new industries should be made available to them;
- long-term lease of government land for setting up windfarms should be permitted; and
- the state government should ensure availability of stable grid at sites where the wind power facilities are to be established (see Table 1).

The guidelines for the state governments also require the creation of a Consultancy Cell to provide technical assistance to private entrepreneurs for planning and implementing wind power projects.

In addition to the guidelines for the state government, the MNES also requires the entrepreneurs seeking to develop wind power projects to satisfy the following conditions:

- entrepreneurs must have financial resources for meeting at least 25% of the project cost;
- if the IREDA loan is sought, the necessary guarantees and/or collateral required by the IREDA must be provided; and
- arrangements must exist with suppliers of wind turbines for supply, long-term servicing, and maintenance.

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[11] MNES 1993, *Strategy and action plan*, Ministry of Non-conventional Energy Sources (MNES), Government of India, New Delhi, February, 1993.

[12] The State Electricity Board would undertake to transmit the power generated by the windfarm to the factory site of the industrial undertaking concerned/unit nominated irrespective of the distance from the windfarm. A 2% wheeling charge implies that 2% of the energy generated by the wind mill farm would be deducted as the Board's commission and the balance 98% only made available to the party at a place where power is required.

Table 1. State government incentives for private sector wind power generation

Items	Andhra Pradesh	Tamil Nadu	Karnataka	Gujarat	Kerala	Uttar Pradesh	Madhya Pradesh
Rates/charges for Wheeling	2% of energy generated	2% of energy generated	2% of energy generated	2% of energy generated (up to June 1996)	2% of energy generated	2% of energy generated	2% of energy generated
Banking	8 months (August to March); 12 months with 2% charge	12 months with 2% banking charges	12 months (July to June with 1 month grace period)	6 months	6 months with 2% banking charges	1 year	Under consideration
Buy-back by SEB	Rs 2.25/kWh	Rs 2/kWh	Rs 1.75/kWh	Rs 1.75/kWh	At the rate at which KSEB will buy electricity from the private sector	Rs 1.75/kWh	Rs 2.25/kWh
Third party sale	Allowed	Allowed with 15% wheeling charges	Allowed	Not allowed	—	Allowed with 2.5% wheeling charges	Allowed to HT (high tension) consumers
Incentives							
Capital subsidy	20% of the project cost subject to a maximum of Rs 25 lakhs	10% of the project cost subject to a maximum of Rs 15 lakhs	As extended to other industries	—	15% of the installation cost subject to ceiling of Rs 5 lakhs	As extended to other industries	As extended to other industries

Items	Andhra Pradesh	Tamil Nadu	Karnataka	Gujarat	Kerala	Uttar Pradesh	Madhya Pradesh
Allotment of land	20 years long lease, free of rent for first 5 years	—	by State Industrial Area Development Board for 40+10 years (renewable)	Renewable 15-year lease	—	For a period of at least 35 years	Lease for a period of 5 years at a token rent of Rs 1 per annum and thereafter at government prescribed rates
Other concessions	Industry status	Exemption from generation tax	Exemption from electricity tax for 5 years for new units	Sales tax exemption/ deferment/ composite benefit towards eligible investment; exemption from electricity duty	Financial assistance from State Development Corporation (up to Rs 90 lakhs); consultancy services	—	Exemption from electricity duty for 5 years; plant and machinery exempt from state sales tax; exemption from demand cut to the extent of 30%; sales tax exemption/deferment/ composite benefit on the eligible capital investment up to 100%; industry status
Single window agency	Non-conventional Energy Development Corporation of Andhra Pradesh	Tamil Nadu Energy Development Agency/ Tamil Nadu Electricity Board	Karnataka Electricity Board/ Karnataka Power Corporation Limited	Gujarat Energy Development Agency	Agency for Non-conventional Energy and Rural Technology/ Kerala State Electricity Board	Non-conventional Energy Development Agency	Madhya Pradesh Urja Vikas Nigam

The measures taken and the guidelines formulated by the MNES have had some impact. For instance, two 100 MW joint venture projects with international wind turbine suppliers have been approved in the states of Andhra Pradesh and Gujarat. Andhra Pradesh is considering a 110 MW, US$ 120 million project proposed by Intervolt Cannon Energy Corporation of New York. Other projects in the pipeline include a 40 MW windfarm in Tamil Nadu, a 20 MW installation in Kerala, and a 30 MW project in Karnataka.[13] According to reports,[14] in response to a request by the government in October 1992, 27 applications were received and approval has been granted in Andhra Pradesh for seven private organizations to set up windfarms with a total capacity of 178.5 MW at an estimated investment of Rs 7000 million. In addition to these, Sree Rayalaseema Alkalies, Madras Cements, Avanti Kopp and Kera Sinters, Shakti Concrete Industries, and NEPC–Micon are each expected to set up 5 MW windfarms at Ramagiri.

Incentives for small hydro development

The investments and/or financing for the small hydro program in India originate from three sources. At the Central Government level the MNES provides subsidy for small hydro programs while the IREDA provides soft loans for the construction of small hydro projects primarily from the revolving funds and loans provided by multilateral agencies like the World Bank, GEF (Global Environment Facility), DANIDA (Danish International Development Agency) and so on.[15] Finally, several state governments have allocated resources for small hydro development.

Financial subsidies by the MNES

The following subsidy scheme is applicable during the Eighth Plan period from the MNES.[16]

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[13] Anonymous, 1993, *Wind Energy Weekly* 12(565), September 27, 1993 (American Wind Energy Association).

[14] Anonymous, 1993, Wind farm in Ramagiri, *The Hindu* (Madras, India), October 8, 1993.

[15] The financial subsidy offered by the MNES or the soft loan available through IREDA is available to any interested implementing agency, either in the public or private sector. The only condition is that *either* the subsidy or IREDA loan can be used but both these facilities will not be available for the same project.

[16] In the recent policy statement of the MNES this has been modified to say, 'under the capital subsidy scheme up to 3 MW capacity, the MNES provides subsidy for various types of projects, whether grid or non-grid, up to 50% of fixed capital cost on E & M (Electrical and Mechanical) equipment and civil works'. See *MNES 1995, Status of Small Hydro Power (SHP) Development Program up to 3 MW capacity.*

- For grid connected projects, the MNES may subsidize up to 25% of the acceptable capital costs of civil works, and electrical and mechanical equipment including generator transformers.
- For non-grid connected projects[17] and projects in hilly regions (whether grid connected or non-grid connected), the MNES may subsidize up to 50% of the acceptable capital cost for civil works, and electrical and mechanical equipment including the transformers.

The subsidies are available for projects implemented by the private, government or cooperative sectors but excludes loss-making private and public sector entities. Furthermore, these incentives are not available for projects aided by any international agency (including the World Bank) requiring international bidding or tied supplies.

IREDA's soft loan financing

Using funds allocated to the IREDA by the Government of India or from external financial assistance (such as the US$ 70 million World Bank loan) the IREDA provides loan assistance for small hydro projects. As indicated earlier, either the MNES subsidy or the IREDA loan can be obtained but both these facilities are not available for the same project.

Loan is provided for up to 75% of the total project cost of eligible items under the World Bank loan, whichever is lower. The principal is to be repaid over 10 years (with a 3-year moratorium) at an interest rate of 14.5% (with a discount of 0.5% for timely repayments). Other conditions may apply depending on the source of funds. For instance, the US$ 70 million made available to the IREDA through the World Bank loan is to be disbursed specifically for setting up of irrigation canal- or dam-based SHP (small hydro power) projects up to 15 MW capacity.

State government incentives

As indicated, regulations related to power generation facilities located in a state is under the purview of the state government and/or the SEB. The MNES has been aggressively lobbying with different states for regulations for renewable energy power generation. The main elements of the regulation sought by the MNES for small hydro (and other renewables for power generation) are similar to that for windfarm power generation. The MNES attempts to get the states to implement policy which guarantees:

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[17] The projects will be taken to be non-grid if an existing grid transformer is more than 2 km from the project site. Further, electricity from the SHP projects not connected to the grid or in hilly regions is to be supplied to the local area at reduced rates. The rate is to be based on the cost of generation calculated after deducting the subsidy from the capital cost.

- wheeling of the generated power;
- banking of the generated electricity;
- a floor level buy-back rate of generated electricity; and
- third party sales of the generated electricity.

Table 2 summarizes the incentives provided by eight states for small hydro power generation. While conditions for wheeling, banking, and third party sales of generated electricity are relatively uniform across the states for wind power generation, similar conditions do not exist for small hydro.

Incentives for bagasse-based cogeneration

A Task Force constituted by the MNES estimated the potential for surplus power generation at 3500 MW in 420 sugar mills in India. It identified financial constraints as the primary hurdle in the penetration of cogeneration technology in sugar mills. High capital investment, almost as much as the investment for setting up the sugar mill itself, is required to set up efficient cogeneration facilities. High interest rates and the low repaying capabilities of the sugar manufacturing sector are believed to be the main constraints in the modernization of the old plants and setting up of efficient cogeneration facilities. Based on these findings, the MNES developed demonstration programs, incentives and financing schemes. In addition to this, the MNES provides assistance for preparing detailed project reports,[18] and has launched technology development programs in the areas identified by the Task Force.

MNES subsidy for demonstration programs

For bagasse-based cogeneration, the MNES provides a one-time non-recurring capital subsidy of 30% of the total equipment cost. The subsidy permissible under this demonstration program for a cogeneration project in sugar mills allows a maximum reimbursement of Rs seven million per MW of surplus power planned to be fed into the grid with preference being given to projects using state-of-the-art technology to generate a minimum of 5 MW of surplus power.[19]

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[18] Grant up to 50% of the cost of the detailed project report, with the maximum grant determined by the surplus power generation identified, is reimbursed by the MNES.

[19] See *Energy Environment Monitor*, 10(1):1 (Special issue on Biomass-based cogeneration).

Table 2. State government incentives for private sector small hydel generation

Items	Andhra Pradesh	Tamil Nadu	Karnataka	Kerala	Uttar Pradesh	Madhya Pradesh	Punjab	Himachal Pradesh
Rates/charges for								
Wheeling	10% of energy generated	15% of energy generated	2% up to 1 MW; 5% up to 3 MW; 10% above 3 MW	12% of energy generated	2% of energy generated; 2.5% for sale to third party	2% of energy generated	2% of energy generated	2% of energy generated
Banking	Not allowed	—	2% up to 1 MW; 5% up to 3 MW; 10% above 3 MW	At mutually agreed rates	Allowed for one year	Not allowed	Not allowed	Allowed with additional charges
Buy-back by SEB	At mutually agreed rates	At mutually agreed rates	—	At mutually agreed rates	Rs 1.75/kWh	Rs 2.25/kWh	Rs 2.25/kWh	Rs 2.25/kWh
Third party sale	Not allowed	Not allowed	Allowed	—	Allowed	Allowed	Allowed	Allowed
Incentives								
Capital subsidy	Up to Rs 15 lakhs per project	10% of the project cost	As extended to other industries	—	—	—	—	—

(Continued)

Table 2 continued ...

Items	Andhra Pradesh	Tamil Nadu	Karnataka	Kerala	Uttar Pradesh	Madhya Pradesh	Punjab	Himachal Pradesh
Other concessions	—	—	Exemption from electricity tax for 5 years for captive use	—	—	• Plant and machinery use for generation free from state sales tax; • Exemption from payment of electricity duty for 5 years; • Exemption from demand cut up to 30% for self use	• Exemption from demand cut; • Sales tax benefit for the owner of the project	—
Royalty on water	Chargeable rate to be fixed	—	10% of the prevailing electricity tariff	Chargeable rate to be fixed	10% of the electricity generated	—	—	Exempted up to 1 MW capacity
Single window agency	Andhra Pradesh State Electricity Board	Tamil Nadu Electricity Board	Chief Secretary, Karnataka	—	Non-conventional Energy Development Agency (3 MW); UP Laghu Jal Vidyut Nigam (>3 MW)	Madhya Pradesh Urja Vikas Nigam	Punjab State Electricity Board/Punjab Energy Development Agency	HP State Electricity Board/ HIM-URJA

Table 3. Incentives declared by six state governments for cogeneration power projects

Items	Maharashtra	Tamil Nadu	Karnataka	Uttar Pradesh	Madhya Pradesh	Punjab
Participation permitted (other than government sector)	Private	Private	Private	Private	Private	Private
Rates/charges for						
Power wheeling	—	15% of energy generated	6% of energy generated	12.5% of energy generated	2% of energy generated	2% of energy generated
Power banking	—	2% of energy generated	-do-	Allowed for 1 year	—	—
Buy-back by SEB	Allowed @ Rs 2.25/kWh >4 MW & Rs 2.2/kWh <4MW	Allowed @ Rs 2/kWh	Allowed @ Rs 1.75/kWh	Allowed @ Rs. 2.25/kWh or at a rate ensuring 16% return on equity, whichever is lower	Allowed @ Rs 2.25/kWh	Allowed @ Rs1.50/kWh
Third party sale	—	Allowed	Allowed	Allowed within a radius of 5 km	Allowed	Allowed

(Continued)

Table 3. continued...

Items	Maharashtra	Tamil Nadu	Karnataka	Uttar Pradesh	Madhya Pradesh	Punjab
Incentives						
Capital subsidy	Participation in equity up to 60% by MSEB for cooperative mills	—	Subsidy @ Rs 25 lakhs per MW	—	—	As extended to other industries
Other concessions	—	Exemption from electricity generation tax for captive use, TNEB, third party	Exemption for 5 years from electricity tax for captive use	—	Exemption from sales tax and other concessions applicable to new industry	Exemption from electricity duty; sales tax benefit; capital subsidy
Promotional supports						
Opening of coordination cell/ single window agency	MSEB (Maharashtra State Electricity Board)	TNEB (Tamil Nadu Electricity Board)	Chief Secretary, Karnataka	Department of Additional Sources of Energy	Madhya Pradesh Urja Vikas Nigam	—
Publication of brochure (detailing policies/incentives, etc.)	—	Published	Published	—	—	—

Financing schemes

Different financing schemes have been developed for different levels of technology used in the cogeneration facility. For sugar mills generating 1–4 MW of surplus power utilizing existing facilities (including boilers, etc.), semi-commercial loans with 10.3% interest (0.5% rebate for timely payments) and a repayment period of 10 years (with a 2-year moratorium) is available from the IREDA.[20] The Sugar Development Fund of the Ministry of Food is likely to provide soft financing scheme for sugar mill-based cogeneration facilities with more than 4 MW surplus power capacity.

State government incentives

Biomass-based cogeneration is another sector for which the MNES has been actively lobbying with different states for providing incentives. The main elements of the regulation sought by the MNES are, again, provisions for wheeling, banking and third party sales of generated electricity.

Table 3 summarizes the incentives provided by six states for cogeneration projects which are not uniform. Charges for wheeling of power vary from 6% to 15%, and three of the six states do not permit banking of power, and electricity buy-back rates vary from Rs 1.5 to Rs 2.25/kWh.

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[20] Other terms for the loan are similar to the standard conditions for the IREDA.

Effects of alternative forms of power sector restructuring on market prospects for renewables: lessons from the US

Jan Hamrin

Background

Pressures for restructuring

The electric utility industry in the United States needs restructuring because of: (i) the introduction of competitive alternatives to traditional electric utility services; (ii) the argument that economies of scale in electric generation facilities (where they exist) can be captured by competitive bulk-power markets; (iii) a widening gap between incremental generation costs and electric utility rates; and (iv) a recognition of the imperfections of some existing regulatory practices.

Competitive options. The passing of the National Energy Act in 1978 and the implementation of the PURPA (Public Utilities Regulatory Policies Act), the repeal of the PIFUA (Powerplant and Industrial Fuel Use Act) in 1985, and the passage of the EP (Energy Policy) Act of 1992 have brought a variety of competitive options (both supply and resource reduction) into the electric utility market. Renewable resources, cogeneration, self-generation, DSM (demand-side management), fuel switching, municipalization and the potential opening of transmission grids are contributing to increased market opportunities for technologies that would otherwise not have been likely to develop. Electric utilities have been required by the federal law and state regulation to purchase power from qualifying facilities[1] and to implement DSM programs. Utilities have also been required to compare demand-side and supply-side resources planning and to provide transmission access to wholesale generators.

Changes in economies of scale conditions. A number of events have taken place which have reduced the importance of economies of scale of the electricity industry; (i) technological stasis of central boiler and turbine generation; (ii) the economic and reliable operation of dispersed generation; (iii) the reduction in the rate of demand growth and the increased lead time, and difficulty of siting and building large generation plants; (iv) the aggregation of smaller generation units and access to markets through the transmission grid; and (v) technology development which allows better grid coordination, dispatch, firming, and pooling.

Increasing cost/price gap. The widening gap between incremental electric generation costs and electric utility rates has a number of potential causes: (i) the sunk costs of past investments (particularly those in large nuclear generating units) have tended to be relatively expensive compared to current generation options; (ii) inefficiencies in the vertically-integrated utility which are indirectly encouraged by some regulatory practices; and (iii) special costs and programs, including state and local taxes, incentive rates for special customer groups, etc. The sunk costs of past generating investments which were more expensive than many present options and the existence of excess capacity pose the greatest problems.

Recognition of regulatory imperfections. Utility regulation has always had imperfections, such as slow, cumbersome legal requirements and processes which are costly for interveners. Now, however, changes in critical elements of the electric utility industry, combined with competitive pressures on energy services and global competition in the business economy, are focusing on the costs and imperfections of some electric utility regulations. Deregulation of other industries and a political environment that promotes increasing reliance on market forces has contributed further to a reexamination of the electric utility regulation and structure.

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[1] Qualifying facilities is a category of generating facilities defined under PURPA that includes cogeneration and small power facilities using renewable resource technologies.

International electric industry restructuring

Restructuring of the electric utility industry is not limited to the US. Indeed, the electric utility sector is undergoing restructuring or being considered for restructuring in several countries around the world. Traditional electric utilities in most countries were originally established as government-owned monopolies. Thus, the ownership and regulatory functions were often exercised by the same government agency.

The majority of the electric utility companies throughout the world have been government-owned, allowing for little, if any, experience in utility regulation of the type used in the US to regulate IOUs (investor-owned utilities). Rates are set by a government body and are highly influenced by politics. In many countries, electric services have been heavily subsidized by the government, and in some places, low-cost electric rates are considered a 'right' regardless of the actual cost.

The capital intensity of the electricity sector reduces the chance for expansion of generation and transmission because of limited funds made available from the government, for which there are multiple and conflicting demands (e.g. for education, health care, other infrastructural needs, police, fire fighting, military, and other uses). Electricity plays a unique role in the economic productivity of a modern society; development and modernization tend to be linked to the expansion and maintenance of electric services. Consequently, increasing the productivity and efficiency of the electric utility sector is a central concern in most countries. The characteristics that all the electric utilities have in common, regardless of their location or structure, are: (i) capital intensity, (ii) substantial market power, (iii) substantial political clout, and (iv) a large potential for causing environmental damage through the generation, transmission and the use of electricity.

Electric utility restructuring may take one of several forms.

Incorporation. A government-owned electric utility operating as part of a larger government agency (or with its funds co-mingled with general funds) is restructured into a separate government corporation with its own management and accounting systems (a separate business center).

Introduction of competition. Competition is introduced, most often into the generation sector. Third parties and private sector companies are allowed to own and operate generation systems (both self-generation and generation of excess power for sale into the wholesale system) in competition with the state-owned utility. This is equivalent to the passage of PURPA in the US.

Privatization. This involves the transfer of a state-owned electric utility or utility function to the private sector. Privatization may or may not involve a structural deintegration of the vertically-integrated utility, or introduce any competition into the utility system. It alters the means of monitoring managerial behavior. In particular, capital market pressures may be brought to bear. Privatization of a 'natural monopoly', such as the electric utility, also involves development of a regulatory structure to protect against market imperfections and abuse of monopoly power.

Vertical deintegration. The vertically-integrated utility is separated into distinct companies according to function. This deintegration is usually associated with other changes such as privatization (in the United Kingdom example), or the introduction of competition (in the Norwegian example). However, in Chile, deintegration was introduced several years before either privatization or competition.

In the long run, the challenge for utility regulators and legislators is to devise new industry structures and regulations which will support environmentally preferred technologies. Regulators and legislators must retain responsibility for the public interest in electricity and promote policies which enhance the environment, equity and economic development. Some of the problems which may be faced by renewables and mechanisms to overcome these by utility regulators are described.

Restructuring proposals and issues in the US

Fourteen of the fifty states are considering some aspect of electric industry restructuring either through their legislature or utility regulatory commission. There are many types of models which have been proposed: (i) improving competition in the wholesale market (by deregulating wholesale transactions); (ii) various power pool proposals for improving efficiency in the transmission sector; (iii) improving competition in resource acquisitions through the use of competitive bidding; (iv) introducing competition into the retail market by abolishing the retail utility franchise; and (v) a combination of these which includes deintegration of the vertically-integrated utility. The following are some of the issues faced by renewables in each of these models.

Wholesale competition

Wholesale competition already exists in the US as a result of PURPA—an Act that introduced technology and ownership competition by requiring utilities to buy power from qualifying facilities (using renewables and cogeneration technologies), which were not owned by the utilities. The passage of the EP Act increased competitive options by allowing non-utility owned fossil generation to compete in the wholesale market and required transmission access to be available for all types of generators at non-discriminatory rates. Pressure is now being exerted to improve wholesale competition by reducing or eliminating wholesale market regulation, and deintegrating the vertically-integrated utility, thus reducing competition from inefficient plants, allowing greater access to the wholesale market, and improving the efficiency of wholesale transactions.

Regulators and legislatures must ensure that market structures and rules of participation are open to smaller, independently-owned, decentralized, and intermittent technologies. Affiliate transactions between the ownership of large blocks of generation and the ownership or management of the T & D (transmission and distribution) systems must be avoided since that will result in major market failures and a competitive bias against independent resource ownership. This bias is more likely to act against renewables than traditional supply resources because renewables tend to be new and not owned by large affiliated entities. The solution to this problem is careful attention to the design and rules of participation of new wholesale market structures. In addition, resources acquired on behalf of customers must be obtained through a competitive solicitation mechanism which encourages green solicitations to ensure a diverse mix of resources. The wholesale market should also use price signals which reward (pay higher prices) power from cleaner generating resources and discourage (pay lower prices) power from dirtier generating resources and use pricing mechanisms that reflect long-term risks in contract prices.

Transmission access

Transmission access is critically important to large-scale development of renewables because renewable generating facilities must be located where the resources are which may not always be near large demand centers. Transmission access must be available at fair and comparable rates (if wheeling charges are assessed) and transaction costs should be as low as possible. This has been a particularly serious problem for renewable resource development in the US.

From the perspective of development of renewables, the wholesale market must incorporate a mechanism to reflect different resource attributes, particularly environmental and diversity impacts. The structure of power pools may foreclose particular policy options in the retail market while the rules for power pool participation can exclude renewables participation.[2] For example, a central pool structure, like that used in the UK, can facilitate the uniform application of various policy tools (like fees, feebates, environmental dispatch, legislative mandates) on all wholesale participants while other structures do not have any mechanism for universal policy implementation.

Competitive bidding

Competitive bidding was introduced into the US electric industry in 1984 to increase competition among non-utility generators and to substitute for an administratively determined avoided cost. Unfortunately, the results have not been favorable for renewable resources. According to the 1993 NREL (National Renewable Energy Laboratory) report, *The Impact of Competitive Bidding on the Market Prospects for Renewable Electric Technologies*, of the 12 000 MW of capacity selected under competitive bidding by 1992, only 12% came from renewables. This compares unfavorably to the PURPA-related qualifying facility development experience of the 1980s of which 40% was renewables-based.

However, renewables are also being evaluated and acquired using green RFPs (Request for Proposals) by a variety of utilities across the country (e.g. California, New York, New England Power Company, Portland General Electric, Bonneville Power Authority, Northern States Power, and Texas Utilities Electric). The primary advantages of green RFPs are: (i) they ensure that some type of renewable resource will actually win the solicitation; (ii) they are much less complicated to structure than a fair, all-source solicitation, since completely different resource types are not being considered in the same competition; and (iii) more renewable bidders are likely to respond.

Retail competition options

Retail wheeling (or direct access as it is sometimes called) is the restructuring proposal at the center of the debate in states where electric industry restructuring is being considered. Essentially, this consists of eliminating the utility retail franchise so anyone can sell electricity to any end-user. In this case, the local distribution utility becomes a 'wires only' business. In practice, no restructuring effort has yet reached this level of retail wheeling. The

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[2] For example, some power pool proposals and future market proposals suggest that only projects over 100 MW which generate firm energy may participate. This could exclude small projects and intermittent resources like wind and solar.

UK which has one of the most aggressive restructuring models, officially offered direct wholesale market access down to customers of >100 kW in load. In actual practice, technical and other problems have prevented even customers of this category from having the choice of direct access. It has also been argued that retail wheeling eliminates the need for resource planning as well as utility DSM and renewables programs. This is the most extreme of the restructuring proposals with regard to the potential negative impacts on the development of renewable resources.

Another retail model is called the Energy Service Company Model. In this case, the distribution utility is encouraged to provide various types of energy services, some as a monopoly provider and others as one of several competitors vying to serve retail customers. This second retail model is much more attractive from the perspective of renewables in that the utility can continue to aggregate the market (especially for smaller customers), provide reliable information, and improve consumer confidence in new technologies like renewables. The distribution utility may also leverage financing, set technology specifications, and inspect installations to ensure that they will operate as they are supposed to do.

Recent public opinion surveys in the US indicate an overwhelming support for renewables (though this is thought to be concentrated in the residential and small commercial/industrial class of customers). From the perspective of renewables, any changes in the retail electric market should focus on ensuring the following: (i) the health and welfare of the citizens is enhanced; (ii) there is fair competition in the retail sector; (iii) there are economic benefits from competition and that they accrue equitably to all customers; (iv) customers are offered meaningful choices among product alternatives; and (v) that customers are sufficiently informed concerning the attributes of these alternatives to make intelligent choices. To the extent that a regulated entity (distribution utility and/or energy brokers) is purchasing resources for sale to the public, portfolio planning and the ability to compare resources and portfolios with different attributes is critical (whether this is called integrated resource planning or consumer product disclosure). Where significant electric utility restructuring is taking place, design criteria should be adopted which incorporate public interest goals and objectives against which new industry proposals can be evaluated. Specific outcomes may be articulated (for example, by the year 2000, all power purchased for resale within the state must meet new source emission requirements) to ensure that implementation details do not defeat program goals.

Deintegration of the sector

Whether the electric utility is government-owned or independently-owned, it is most frequently vertically-integrated with all services being provided by the same company. One of the first topics on a restructuring discussion list is whether the utility would function more efficiently if it were deintegrated.[3] This assumes even greater importance when the electric utility is privately-owned and involved in a mixture of competitive and noncompetitive transaction. A few of the reasons investor-owned utilities are regulated are to oversee utility transactions, ensure that ratepayer interests are being protected, and that the utility is not abusing its monopoly power in competitive markets.

An expressed objective of many restructuring models is to reduce the need for regulation. However, one of the prime reasons that the so-called command and control regulation is needed is because the vertically-integrated utility structure, which presently includes a mixture of competitive and noncompetitive sectors, has the potential for conflicting ratepayer/shareholder agendas and opportunities for internal cross-subsidies and anti-competitive behavior. Where there is a desire to increase market competition (through the use of a PURPA-type mechanism, competitive bidding or a more radical form of restructuring), these conflicting agendas can cause serious problems.

Without deintegration, the need for tight regulation will remain. Attempts to substantially reduce regulatory oversight or to increase competition are likely to result in the abuse of monopoly power and a highly stressed utility regulatory commission. All the countries already involved in the restructuring of their electricity industry have found it necessary to separate (deintegrate) the ownership of the generation, transmission and distribution sectors.

In the US, from the perspective of meeting public service goals to the significant uneconomic assets burdening the rate structure, there will be pressure to pass on those costs to others and to cut everything but the cheapest minimum service in order to reduce short-term rates. Smaller customers, renewables, energy efficiency, and R D & D (research, development and demonstration) will suffer as a result; to the extent that stranded investment strategies are not developed early, are inadequate, or inequitably distributed, utilities will resist any significant restructuring and the electric industry will become paralyzed, resulting in a major setback in the ability to meet national and state environmental and public interest goals.

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[3] This separation of the major business functions into individual companies (i.e. generation, dispatch/control, transmission, distribution) is also called disaggregation, disintegration, delamination or divestiture.

New roles for existing stakeholders

When discussing the fundamental changes required by the electricity industry, one must be concerned about the potential role changes for existing stakeholders (i.e. government regulators or agencies which oversee government-owned utilities, utility managers, regulators, independent power producers, and even consumers). Though many of the potential changes being discussed may have very positive consequences in the long-run, in the short-run there is always the momentum to keep things as they have always been.

State regulators

State utility regulatory practices, which now shape electric utility resource planning and acquisition programs, have been the critical factor in affecting the degree to which nontraditional resources, such as renewables, have actually been incorporated into an electric utility's resource mix. For example, in the US, those states with long-standing policies toward implementing PURPA have had the greatest success in renewables development. There were also two serendipitous side-effects of PURPA: (i) paying for performance, rather than cost-plus regulation was more economically efficient for the ratepayer; and (ii) the quality of regulation improved due to the introduction of more participation into the planning and resource acquisition process.

The electric utility role

Electric utilities and their customers are the ultimate market for many renewable energy technologies. Direct purchases from or investment in renewables can provide utilities with concrete quantification and valuation of the benefits which renewables can bring to the utility system. Unfortunately, in the US there were a number of institutional barriers to utility involvement in renewable technologies. Regardless of the cost or technical performance, many traditional utility managers would have refused to purchase, install or buy power from renewable resources. Because the PURPA requires utilities to purchase power from renewable facilities, some of this institutional inertia was removed. However, to some extent, it was replaced with resentment against being told what to do. This was magnified by the fact that some independent power projects made utility projects look inefficient by comparison. Most importantly, the independent power projects displaced utility projects which would otherwise have been built by the utilities and from which shareholders would have earned a profit.

In the future, the challenge for US electric utilities is to define their changing business niche. What business do the utility companies want to be engaged in ten years from now, and what is the best path for them to get there? There is also a dilemma concerning the future role of utility shareholders. In the past, utility investments in the US had been thought of as very secure, with gradual but consistent returns to their owners. This may not be the case in the future. Competitive markets tend to be highly volatile. Profit margins may be reduced or could even become losses. Are shareholders better off investing in separate utility operations (i.e. generation, transmission or distribution) where risk profiles and profitability can be more clearly defined? This is an interesting problem for the future of the US investor-owned utility industry.

Conclusion

The development of renewable energy resources offers us clean power from indigenous energy resources. Many renewables have already proven to be commercially viable and reliable resource options in the utility sector. Over the last two decades, the costs of many renewables have declined and technology performance has improved; it is expected that these improvements will continue. However, the pressure of utility competition and restructuring will undermine renewables unless care is taken to assure their continued development.

The substitution of more competitive market structures for regulation significantly reduced the state policy mechanisms available to influence the electricity sector. In a market-driven system, there are few mechanisms and even fewer leverage points through which public interest objectives can be implemented. Substantial barriers to the development of renewable energy resources persist in the electricity market today. Any new industry and regulatory structure should be designed to reduce rather than increase market barriers to renewable resources.

Solar power for earthly prices: the rest of the story

George J Sterzinger

As a result of the Enron Corporation proposal to build and sell 100 MW of solar electricity at the down-to-earth price of 5.5¢ per kWh, solar energy—thin-film photovoltaics in particular, is at a new and exciting threshold. A headline in the *New York Times* announced: Solar Power for Earthly Prices (15 November 1994). Unfortunately, the story completely missed the other half of this breakthrough. It is not a success for Enron where government efforts failed. The Enron project uses supports such as land, low cost capital, and a long-term contract provided as part of a new federal strategy to technology commercialization.

This new strategy argues that if basic R & D (research and development) has been successful, and if creative ways to integrate and build support for initial commercialization of these technologies can be found beyond traditional and very scarce federal appropriations, then developers will come forward to put solar energy firmly on the ground. This new strategy is designed to encourage substantial activity in renewable energy commercialization at a time when public resources are dwindling. Rather than showing a failure of government efforts, the Enron proposal shows this new commercialization strategy to be fundamentally right. The public half of this effort was put together in a workable manner.

Firstly, the government's R & D funds nurtured the development of thin-film and several other types of photovoltaic technologies to the point of readiness for commercialization. A critical assessment of technology R & D, 'The Technology Pork Barrel', favored the photovoltaic R & D effort calling it 'sensible from both a practical and a theoretical perspective ... the interim cost reduction goals had been met, and with an expenditure of only about half the original amount deemed necessary'.

Secondly, government policy towards the commercialization of these technologies has become increasingly sophisticated, even graceful, at encouraging the best private initiatives to pursue important private and public agendas at little cost to the public, indeed with the possibility of a windfall in cases of successful commercialization.

New technologies that successfully go through research and development still face a difficult transition to marketplace success. Initial commercial projects often face substantial cost penalties because first time construction of anything is expensive, and because components for these initial projects are often manufactured at a scale well below those that minimize cost. These cost penalties increase business risk which in turn raises financial risk pushing project costs still further.

The public or federal task in the commercialization partnership is to identify the public agenda—which technologies from an environmental and energy security perspective are important to pursue—and to assemble supports to reduce the cost penalties associated with initial projects that are just enough to entice private developers.

Federal involvement in this new strategy began with the 1994 Defence Reauthorization Act. Senators Bryan and Reid of Nevada requested in the Act that the DOE (Department of Energy) assess the commercial feasibility of solar power development at the NTSF (Nuclear Test Site Facility). The DOE responded enthusiastically to this request, working with National Laboratories and others to complete the initial feasibility study of the NTSF, a 1400 square mile reserve with little anticipated use due to the testing moratorium. Maps of the sunlight intensity in the US show concentric rings of increasing intensity, reducing to a bull's eye almost squarely over that portion of Nevada. Just one-half of one section or about 7% of the total land available, will support 10 000 MW of solar power development or about 10 Hoover Dams. The DOE and Senator Bryan have co-chaired a high level Task Force to identify and focus all possible supports for solar commercialization. As a result, the Nevada NTSF will offer land and resources for solar power development as a solar enterprise zone. In addition, the Task Force recognized that creative financing is critical to large-scale solar commercialization projects. Rather than relying on direct federal appropriation to reduce project costs, the Task Force is recommending access to tax-exempt financing to support commercialization efforts. Instead of simply providing support, the Task Force is highlighting that the public share gets enhanced in the commercial success of the programs. As a result, large public funds for commercialization are pooled, and taxpayers can make money on successful projects. Market aggregation, finding a buyer and a good price for the output, is also part of the expanded public role.

All these functions come under a Development Authority, directed by federal, state and public representatives, charged with expanding the commercial market penetration of solar power, capturing the environmental benefits of that technology, and expanding export potential.

While the fundamental roles of the public and private partners in these commercialization efforts are unchanged, this new strategy is an improvement in many ways. Public supports are integrated from such diverse sources as unneeded military land to very creative financing packages. Finally, and most importantly, this new package seems to be working. The ink is not dry on the final Task Force recommendations and the solar industry has a smoking success. As brilliant and daring as the Enron proposal is, there are many solar technologies and developers eager to follow Enron, to commercialize other solar technologies and step smartly into the energy marketplace of the twenty-first century.

The name game: the electricity market of the future

Jan Hamrin

The view from the trenches of electric industry restructuring is a little like watching that cult television program of a few years ago 'Twin Peaks'. There is a large cast of characters but it is difficult to figure out their relationship to each other. What you think is going to happen changes from episode to episode. Sometimes the plot seems like a murder mystery, other times like a soap opera and still other times a black comedy. Some segments seem to run in fast forward and others in slow motion. Finally, though they are always supposedly speaking English, it is frequently difficult to figure out what they are really talking about. And even after it was over, you wondered what it all meant. What follows is a brief interpretation of what electric industry restructuring may mean for the use of wind generation in the future.

What is driving the restructuring?

In some respects, electric industry restructuring is a holdover from the 1980s—deregulate industry and get government out of the way of business. Electricity is the last vertically integrated, heavily regulated US industry which makes it an unfinished business on the political agenda. Because of its capital intensity, there are large amounts of money at stake—billions and billions of dollars. Problems with the US economy and the global marketplace are putting increasing pressure on US businesses to cut costs wherever they can. Local economic problems and the expanding gap between the rich and the poor is fueling social instability and exerting pressure for rate relief from customers. A loss of clarity on important social values is encouraging business to focus only on the short term and grab profits however they can. There is money when a major institution is in the process of change. There are opportunities to redistribute market shares, shift costs onto others, and profit from confusion and disorder. Electric industry restructuring is being debated by economists but a non-academic driver is greed.

In addition to other issues, key stakeholders have major questions which cannot be unilaterally resolved. The electric utility's dilemma lies in determining what their business will ultimately be. Utility shareholders have to face the problem of how different restructuring proposals will affect utility investments. The state utility regulator's dilemma is the uncertainty of what their future role and jurisdictional authority will be. Electric industry customers need to decide what choices they want at a time when the majority do not know about, let alone understand, the restructuring debate. Finally, the supplier's dilemma (i.e. wind project developers) lies in trying to figure out what the new industry market might look like, who constitutes the competition and what are the strategy options that should be supported.

Why are renewables important?

This may seem like a strange question to bring up at a meeting of renewables advocates but it is important to review the arguments which are used to justify renewable resources having a place in future electric markets. Industry advocates may believe that renewables are the socially correct resources for electricity markets of the future. Environmental advocates may believe that renewables are the environmentally correct technologies for future markets. Renewable energy companies may believe renewables are the correct business investment for future markets. But the economists and anti-regulation advocates are driving the present agenda. They argue that if renewables are not competitive, so be it. Weeding out uneconomic investments is what market-based systems are all about.

A major challenge is to develop a sound argument as to why decision-makers should be concerned about ensuring that renewables have a place in future electricity markets. One answer in economic terminology is that renewables can act as a hedge against a variety of market risks—fuel price risks, risks of changes in environmental regulation, and short-term market price volatility, etc. All these risks represent potential costs to customers within the next decade. Market-driven systems have the potential to directly expose customers to a variety of risks. Resources can be (or resource contracts) acquired as part of a portfolio which is designed to hedge against those risks.

In addition, renewables such as wind can provide public interest benefits with which decision-makers charged with protecting the public's interest must be cognizant. New generating technologies tend to be environmentally cleaner than older technologies. Yet without careful planning, market-driven systems can discourage the use of new, more efficient and environmentally preferred technologies. None of these arguments may be sufficient in themselves, but together, they represent an important part of the design criteria against which new industry structures should be measured.

Future market scenario for the electric industry

It is not simple to predict the future since it is likely that initially different states will try to implement different models. There are four basic market scenarios which could evolve simultaneously in different states around the country:

- the Expanded Wholesale Market Model;
- the Direct Access/Retail Wheeling–Wires-Only Utility/Retail Brokers Market;
- the Energy Service Model; and
- the Transitional Industry Model (some hybrid of increased competition within a semi-vertically integrated utility structure.

Primary characteristics of various market scenarios and issues for renewables

The following is a brief description of each scenario assuming that they take place within the current political, economic, and environmental context. Any significant change in the social and political context will affect the form and function of the market scenario.

The Expanded Wholesale Market Model

In this model, the generation sector is deregulated and the transmission sector becomes a common carrier which operates the grid, provides the control functions for the grid and maintains power quality and reliability. Many of the issues affecting the development of wind generation within this model are ones with which the wind industry is already aware:

- the potential for abuse of market power and the opportunity for market consolidation which could block smaller companies from entering the wholesale market;

- the potential for market abuse if there are still business or economic connections between the distribution or transmission companies and the owners of generation facilities;
- the difficulty of a capital-intensive technology competing against fuel-intensive technologies with lower fixed costs (even where they have similar life-cycle costs).
- the need for environmental benefits/costs to be reflected in the short-term as well as the long-term price of power;
- the difficulty of financing new resources in a market driven by short-term prices;
- the need and cost of firming intermittent resources such as wind in order to market them as a commodity;
- the need for some market push from retail customers who have indicated a preference for cleaner technologies;
- the need for an expression of the public's interest in cleaner generating technologies which can be translated into market actions; and
- the difficulty of siting new generating facilities when need is no longer a criterion.
- The type of power pool structure selected (whether a poolco/market-maker form or a bilateral contract form) and the rules which govern participation and access to the pool may directly affect renewables. The rules which govern participation and access to the pool and industry structure (e.g. if or how disaggregated, allowable affiliate relationships, relative size of generation owned by a single owner) are probably more important than the type of pool structure selected.

The Direct Access/Retail Wheeling Model

In this model, in addition to a highly competitive wholesale market,[1] there is a highly competitive retail market. The utility franchise has been abolished and customers arrange with retail brokers for their power needs. The remaining retail utility acts as a distribution 'wires' and billing company only. This model includes all the issues from the wholesale model plus:

- the difficulty of competing at the retail level against short-term electricity prices from fossil-fueled plants (especially new, large natural gas facilities);

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[1] It is possible to imagine the implementation of a competitive retail model where the wholesale market is still regulated. That would be a 'transition model'. The retail wheeling model described here incorporates the assumption that the wholesale market is deregulated.

- the possibility that large electric users will purchase only from the lowest cost suppliers and/or that brokers representing large fossil fuel facilities with parent companies who are affiliated with gas and electric utilities will corner most of the large customer market;
- the difficulty of aggregating smaller customers who might prefer renewable-based power into buyers groups;
- the need, cost, and availability of good customer information for direct marketing;
- the need and cost of increasing customer awareness of long-term benefits/risks of various types of resource portfolios;
- the potential for advertising to focus more on the image than on significant product differences, and the opportunity for major customer rip-offs by unscrupulous brokers. Negative public reaction could hurt brokers representing renewables more than brokers affiliated with large, brand name companies (i.e. gas or electric utility affiliates); and
- the difficulty of finding policy tools that can influence the portfolio decisions of a diverse mix of power brokers as well as millions of individual customer choices.

Energy Service Company Model

This model has all of the issues from the wholesale market model. However, this model has the potential advantage to avoid many of the issues associated with the retail wheeling model if the distribution utility (i) can act as a market aggregator; (ii) takes advantage of its ability to collect good customer information; (iii) has the ability to inform the public about the differences between various supply portfolios; and (iv) instills more customer confidence than independent brokers. On the other hand, the energy service model has the added problems of :

- the need for a mechanism which can directly translate customer preference for renewables into market action;
- as with the retail model above, consumer protection mechanisms are needed to protect against unfair business practices by independent brokers. There also needs to be some mechanism which allows informed comparisons between utility portfolios and broker portfolios;
- the need for a regulatory structure (for distribution utilities) which exposes portfolios of distribution utility acquisitions to fuel price and environmental risks so as to encourage hedging contracts;
- regulatory rules of conduct which prevent unfair competition by the distribution utility with brokers who market directly to retail customers; and
- regulatory mechanisms which (a) encourage distribution utilities to offer

customers a variety of meaningful choices in both the supply of electricity and other energy services; (b) offer incentives for purchasing distributed generation which improves the utility's operational efficiency; and (c) reward environmental performance.

The Transition (or Hybrid) Model

This is potentially the most dangerous model for renewables/wind developers in that: (i) all states/utilities are likely to go through this phase; (ii) it is very easy to combine the worst elements of several models thereby killing the momentum for renewables and increasing the difficulty of obtaining an end model which is friendly to renewable resource development; and (iii) it is difficult to design a transition model which maintains the momentum for renewables. The issues include:

- the importance of regulators dealing with historical investments (i.e. potential stranded investments or assets whose costs are in excess of market prices) as a first step in conjunction with disaggregation of the vertically integrated utility. However, this must be handled in a balanced way so as not to place a high transition fee on existing ratepayers which makes it even more difficult for utilities to buy renewables; or not allow any recovery of historical costs causing the financial community to increase the cost of capital for generation projects and to be wary of any future power investments in that state;
- the pressure on regulators to provide direct access to large electric users as the first step in industry restructuring. This could result in either (a) the existing utility offering these customers very low rates to keep them on the system; and/or (b) brokers representing low-cost, excess power on long-term contracts selling to the large customers thus increasing the stranded investment costs for the remaining customers and potentially driving the system to a less friendly model for wind generation;
- the possibility of adopting a transitional industry model which is not compatible with a final 'renewables-friendly' industry model making it very difficult 'to get there from here';
- the potential to reduce regulation (including PBR[2]) due to competitive pressure on utilities without reducing the need for regulation. This could

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[2] Performance-based regulation (PBR) is a regulatory mechanism which attempts to link rewards (generally profits) to desired behavior. Rates, components of rates or revenue requirements are set for a period of time based on external indexes rather than a utility's cost-of-service. If costs are too high, PBR is not likely to improve the situation and may make things worse by locking rates to existing revenue requirements.

result in increased abuse of market power and a deteriorating market position for renewables;

- leaving a vertically-integrated industry structure in place while trying to encourage competition can result in market abuses of all types and the kind of open warfare between utilities and non-utilities suppliers as exemplified by the current media and regulatory battles in California; and
- the temptation to leave environmental and other public interest responsibilities to some other decision-making body and/or defer action on them to a later time. This can lead to loosening political leverage (to ensure that these public interest issues are an integral part of the new industry), and may result in no one taking responsibility or in delay which has the effect of limiting policy options and making integration of public interest issues very difficult.

Primary decision points for renewables in industry restructuring

The primary decision points for renewables in industry restructuring are alluded to in the issues list associated with various market structures described above. Specifically they include the following:

General

Disaggregation and historical cost decisions. One of the prime reasons that a so-called command and control regulation is needed is the vertically-integrated utility structure, which presently includes a mixture of competitive and non-competitive sectors, conflicting ratepayer/shareholder agendas, and opportunities for internal cross-subsidies and anti-competitive behavior.

Two important principles to guide disaggregation decisions include: (i) the need for structures and policies which align ratepayer and shareholder interests, and (ii) the potential to close generation plants when that action would reduce costs or yield environmental benefits. Without disaggregation, the need for tight regulation will remain. Attempts to substantially reduce regulatory oversight or increase competition are likely to result in the abuse of monopoly power and a highly stressed utility regulatory commission.

Disaggregation also allows parties to consider, in advance of taking action, how to identify and value any stranded investment costs, as well as alternative policies and methodologies for determining to whom and how such costs will be allocated. Without disaggregation, stranded investment costs will develop as customers leave the system for other suppliers. These costs could become higher than under a managed disaggregation strategy and their allocation more contentious as customers scramble to avoid the ever mounting burden, and Commissions scramble to react.

From the perspective of meeting other public service goals, to the extent that there are significant uneconomic assets burdening the rate structure, there will be pressure to pass those costs on to others and to cut everything but the cheapest minimum service in order to reduce short-term rates. Smaller customers, renewables, energy efficiency and R D & D (research, development and demonstration) will suffer as a result, to the extent that stranded investment strategies are not developed early, are inadequate, or inequitably distributed, utilities will resist any significant restructuring and the electric industry will become paralyzed, resulting in a major setback in the ability to meet national and state environmental and public interest goals.

Wholesale market decisions. Disaggregation should greatly improve competition at the wholesale level.[3] However, other decisions must be made to achieve an efficient wholesale market. A power pool to accommodate short-term transactions will be a key component of any wholesale market. The type of power pool and its operating rules will influence and constrain the use of other policy and regulatory options.

From the perspective of environmental objectives, the wholesale market must incorporate a mechanism to reflect different resource attributes, particularly environmental and diversity impacts. Successful implementation of a fully competitive market (including the incorporation of environmental effects) requires structural, institutional and market rules that eliminate market barriers to efficient environmental results.

Power pool (dispatch/control). Other countries have found that the formation of a regional power pool is essential to accommodate the day-to-day operation of the wholesale market. However, because the structure of the power pool may foreclose policy options in the retail market structure, it is important to decide what final structure is most desirable in restructuring goals before making a decision on the type of power pool structure to be used. The two primary options are: (i) a power pool that performs the dispatch of power based on bilateral contract and short-term bid prices, or

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[3] Since optimal wholesale competition is a primary goal of restructuring, the design and timing of new wholesale market strategies, their compatibility with stranded investment and transition strategies are critically important. Moreover, new ownership patterns (including the potential for reconsolidation) for the divested generation become key factors which will allow or constrain entry of other competitors such as wind.

(ii) one that performs dispatch based on a market clearing price for the short-term market (a multilateral contract market). The second option offers a mechanism for implementing environmental policies and instituting special fees which apply to all players. The rules under which any power pool operates are of particular import for wind. Under certain structures, intermittent resources cannot participate because the institution will not allow it.

Separate transmission company. Some believe that transmission system ownership should be separated from the management of the power pool to prevent the collection of monopoly rents associated with transmission constraints. This problem may be controlled through market rules, by preventing the transmission company from owning any generation (even storage) which can be used to run the system, and by regulatory oversight to allow entry by other entities that might be willing to provide alternatives to constrained transmission. With these caveats, the ownership of the transmission system does not have to be separate from the power pool (though that may be a cleaner way of managing the problem).

Environmental strategies. With a move to the greater use of competition, it is essential that there be a mechanism for incorporating environmental impacts into the short-term wholesale market decision process. There are four sets of environmental strategies that might be used to influence the mix of generation resources sold in an unregulated wholesale market: (i) pollution taxes and tax credits; (ii) feebates or environmental dispatch; (iii) state mandates; and (iv) subsidies. From a theoretical standpoint the most efficient mechanism would be the use of pollution taxes. However, in today's political climate, state mandates, environmental dispatch and feebates are more feasible.

Distribution utility/retail market questions. There are four design criteria that should influence decisions regarding the ultimate role of the distribution utility and the functioning of the retail market. The first is the development of mechanisms that provide hedging strategies to moderate the volatility of a wholesale commodity market. The second is to include meaningful choices for smaller consumers in the initial program design and a mechanism for translating a consumer's desire for environmentally preferable resources into market action. The third is to use the distribution utility's technical expertise, credibility, and ability to aggregate markets to increase market opportunities for energy efficiency and on-site renewables while providing the utility a viable business and value-added products. The fourth is the use of consumer protection programs to inform consumers of potential resource risks and to protect against poor quality service.

Technical innovation

Commercialization and integration research requires an interrelated mechanism to facilitate the introduction of new, efficient, and environmentally-beneficial technologies into the electric system. A program must be developed which evaluates new technologies and their potential impacts on the electric system as well as a mechanism which allows new technologies to be sustainably developed (commercialized) within a market-based system. This can be accomplished through federally funded programs or through some type of system-wide fee. Political conditions will dictate the form of this mechanism.

Regulation

There are three fundamental options for regulation of the electric industry: (i) deregulate where the need for regulation is eliminated; (ii) reregulate to a lighter form where the need for regulation is reduced; and (iii) maintain traditional regulation where the need for regulation remains unchanged. The first option, to reduce the need for regulation where that is feasible, is what is envisioned in the generation market and the customer-funded energy service market. However, it is very important that, to the extent possible, the market structure and rules of conduct be designed to contribute to stimulating a fully competitive market rather than an oligopoly, consolidation, or conditions which encourage the abuse of market power.

In utility service areas that are either not subject to competition or where competitive markets have not yet developed, existing regulatory mechanisms may be largely retained or a form of PBR may be used to regulate. The need for regulation, even in these monopoly areas, has been reduced (by eliminating conflicting agendas and aligning ratepayer and shareholder interests). PBR offers a less complicated, more flexible option to traditional cost-of-service regulation. The utility should acquire both demand reduction and supply resources (or bilateral contracts, contracts for differences, either as part of portfolio options or as separate energy services) through competitive bidding solicitations. Shareholder benefits would be determined (using PBR) by the efficiency with which the resources are acquired and meet customer performance and economic criteria. PBR for the transmission sector or the wires-only portion of the distribution sector will look different from PBR for an energy service company.

Performance-based regulation should fit the political framework of the industry in addition to the structure of the utility companies. To be effective, PBR must have a strong, well articulated set of policy goals which specify the desired utility performance. It can be a transition or an end goal but its use requires great care and attention to detail to design a system which balances risks and rewards and provides the desired results. If the need for regulation has not been reduced, PBR will be an unsatisfactory and frustrating exercise for both regulators and ratepayers.

Some of the key PBR issues for renewables are:

- the inclusion of an environmental performance factor;
- the inclusion of fuel price and other supply risks within the PBR 'box';
- disallowing balancing accounts for fuel prices and power pool prices;
- creating a mechanism for evaluating the performance of portfolios. Retain IRP (Integrated Resource Planning) principles as the basis for resource choices and portfolio evaluation;
- incorporating an incentive for the use of distributed generation for the deferral of transmission and distribution expansions; and
- creating incentives for the demonstration and commercialization of new, environmentally beneficial technologies (do *not* put R D & D into a general performance box).

Important policy tools for wind generation under different scenarios

The basic tools for implementing public policies are: (i) fees/taxes/subsidies (federal/state); (ii) licenses/certification (federal/state); (iii) economic regulation (through state utility regulation); (iv) siting/permitting (primarily a state activity); and (v) through state and federal statutes (health and safety—state; anti-trust—federal; environmental—federal and state).

Under the current political environment, fees/taxes/subsidies and economic regulation are expected to reduce in importance. There are opportunities for placing fees on the transmission and distribution wire services but only in very limited amounts. From a public policy standpoint, transition fees (stranded investment recovery) and universal service fees will probably receive top priority with low-income DSM (demand-side management) and with demonstration/commercialization next on the list. If environmental costs are also incorporated into these fees, there is no room for anything else, and, in fact, the politically feasible level of fees for the top priority items may be less than needed.

Siting and permitting could become a problem for all new generation facilities (including wind) and state or federal statutes require enforcement mechanisms which could be difficult without strong state utility regulation (which has provided the enforcement tool for past statutory requirements).

State and federal statutes (under a reduced state utility regulatory scenario) would now rely on civil and criminal penalties which can take long periods of time and very deep pockets to enforce. The policy recommendations suggested here take into consideration these political realities. A changed political atmosphere which supports pollution taxes would make the design of a restructured industry which is friendly to renewables much easier.

There are three primary policy areas for encouraging wind generation under any of the three scenarios described above; institutional structures, rules governing participation and conduct, and the interaction between markets. A critical first step is to get the market structures right so that:

- the power pool/transmission entity is indifferent where the generation is being transported;
- the distribution utility is indifferent to the entity with which they sign bilateral or hedging contracts;
- any transition costs are equitably distributed among all customers (not just captive, smaller customers); and
- the distribution utility functions as an energy service company.

The second area is to ensure that the rules of entry and conduct are designed so that:

- the wholesale market has no entry barriers to exclude non-utility or intermittent resources from participation;
- transmission pricing is based on equivalent capacity and not nameplate capacity;
- both the wholesale and retail markets internalize real environmental costs and discourage the operation of old, dirty generation or require a specified amount of renewables in all retail resource portfolios.
- distribution utilities offer customers choices of supply portfolios and facilitate other renewables services to customers; and
- some type of demonstration/commercialization program is implemented to bring new technologies into the marketplace.

For proper interaction between the wholesale and retail markets, it is important that:

- all resource acquisitions made on utility service customers be acquired through a competitive solicitation;
- rules and regulations be developed which encourage hedging contracts to stabilize prices and mitigate long-term risks;

- there be a mechanism to translate consumer preferences into wholesale market action (meaningful customer choices);
- if direct access is allowed, access should be granted for small as well as large customers; and
- all power brokers be licensed and file disclosure statements.

In the wholesale market, the primary policy level is the power pool since it is the one place where all the players can be affected. In the retail market, the key policy lever may still be the distribution utility, particularly if they have a structure which aligns the interests of the shareholders and customers and makes them indifferent to who owns the power they are buying. In this revitalized role, the distribution utility can be a major ally in providing market and customer information, inspiring customer confidence, market aggregation and translating customer support for renewables into market action. An effective consumer protection program is particularly important for renewables to ensure fair competition and informed customers. The renewables community should forge strong alliances with consumer advocates and representatives of customer groups who may form the foundation of support for the acquisition of power from renewable sources.

As mentioned earlier, T & D (transmission and distribution) fees are another attractive policy lever, however, competition for those fees will be fierce and the amount of total fees tolerated under a competitive market scenario very low.

What else needs to be done?

There are three other tasks which need to be undertaken to facilitate the market for wind generation under a restructured industry scenario regardless of the market model. They include: (i) creation of an institutional structure for firming and marketing intermittent power and simplifying the transmission of power over long distances (through several utility service areas); (ii) development of a mechanism to reduce the cost of financing capital intensive, modular technologies like renewables which reduces the level of debt service over the early years as well as reducing the total cost of financing; and (iii) working closely with state and regional siting agencies to facilitate the revisions to siting rules in a way that does not prejudice new power projects, particularly renewables.

A Renewable Power Marketing Authority (R-PMA)

Institutional mechanisms need to be put into place for aggregating, firming and transmitting renewable resources, including the reinforcement of transmission corridors to move renewable power from major resource areas to major demand areas.

These mechanisms are necessary to enable renewables to participate in a wholesale commodities market. With this strategy, renewables can be marketed where the loads are located even though the renewable resources themselves may be located in distant areas. The strategy must also allow intermittent resources like wind to be packaged as a commodity and marketed in sizes that reduce transactional costs in a large and complex wholesale market.

An R-PMA is one option. Such a structure can be combined with local economic development and agricultural programs with the potential for many economic as well as environmental benefits. R-PMAs can accommodate both large windfarms as well as aggregate power from smaller individual wind generators.

This can be done through a variety of informal or formal structures from the perspective of aggregating and firming power. Marketing and transmission issues require a more complex organization. Even with a fully implemented and open transmission access policy, the transactional costs of negotiating wheeling agreements with more than two or three utilities could make it impractical to develop large quantities of renewable resources in the middle of the country for sale to rapid growth areas on the east and west coasts. What is needed is something akin to the markets from where the crops were grown and goods manufactured. Presently, what exists is the electrical equivalent of surface streets and country roads controlled by local jurisdictions. The major exceptions are the PMAs. An R-PMA could be created through the redesign of existing PMAs or could be a separate entity which would market renewables with priority rights on PMA transmission lines. Regional or state power pools can work cooperatively with an R-PMA.

Financing instruments

New renewable wholesale generation projects will be difficult to finance in a market-based utility structure that is heavily focused on short-term trading. The higher fixed-cost component and time necessary to repay the debt on wind projects makes them appear riskier and more costly initially than fuel-based resources. To the extent that some wind projects[4] are more expensive than fossil fuel projects, this will increase their risk profile. Moreover, traditional financing instruments for high fixed-cost, long-lived investments tend to be levelized over the life of the debt. The market mechanisms included in competitive models tend to favor low first-cost resources. Renewables and energy efficiency are likely to be high fixed-cost resources (manufactured energy) rather than a commodity type (fuel-based, low fixed-cost) resource. Therefore, even when renewables such as wind can favorably compete on life-cycle cost, the first-year costs will hurt them.

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[4] Such as the first projects constructed in new resource areas.

A new financing instrument is needed which can aggregate projects (hedging against individual risks) and begin debt payments at a lower level, increasing them over the financing life as the nominal dollar value of power rises with inflation. Such a mechanism can be accomplished by securitizing a group of renewable (and DSM) investments and using bond financing. This can be done in conjunction with the R-PMA or through some other type of quasi-governmental organization. Another financial tool that may be needed is a purchase contract for wholesale market transactions that inversely ties renewable capacity payments to fossil fuel prices if part of the payment for renewables is based on the marginal dispatch price of the pool (which varies with fossil fuel costs). This would act as a hedge (for both the renewable developers and ratepayers) against fossil fuel price changes and would be an efficient mechanism for encouraging resource diversity.

Regional Power Plant Siting Standards

Prior to or in conjunction with deregulation, state or regional siting standards and guidelines for new, repowered, and life-extension generating plants need to be implemented that incorporate competitive costs, environmental impacts, (air, water, and land-use), other values (e.g. risk mitigation), and regional supply status. Environmental degradation and inefficient use of resources could result from siting and building redundant generation facilities (or facilities that operate for only a short period of time) in a situation where long-term need assessment (including an evaluation of alternative options) is no longer a relevant part of the siting process.

Siting new bulk generation facilities without a CPCN (Certificate of Public Convenience and Necessity) can become a major barrier to new generation. Because renewables such as wind are just moving into the competitive wholesale market (just being built) and because these projects tend to have a larger overall footprint than do fossil plants, new rules and siting standards will be required to facilitate their fair consideration. If the public becomes alarmed about the number of new generation plants being proposed, the NIMBY (not in my backyard) syndrome could increase general opposition to all generation. Renewable projects which tend to have a larger footprint, and under most scenarios enter the market after repowered and new fossil plants, have the potential to suffer the most from ambiguous siting criteria. If some technologies are preferred for environmental reasons, state, regional and national policies should be developed to assist in their siting, particularly where they will replace more polluting generation sources. State resource agencies or new regional siting authorities may assume more siting responsibilities than they have had under some traditional utility structures. The renewables industry should work with these agencies to ensure that new siting policies favor cleaner technologies such as wind.

Conclusion

It is easy to make major mistakes in restructuring which would work against renewable technologies such as wind. It is also difficult to do the restructuring right. Under most scenarios, policy options and levers for removing market barriers to the use of wind generation are much more limited than they have been under the traditional electric industry structure. Funds for special programs and priority resources will be very limited. The wind industry must be creative in thinking about the strategies and policies which are compatible with a market-driven system. The industry must forge new alliances with entities which share similar interests and certainly the National Wind Coordinating Committee is a good start.

A valuable activity for the renewables community is to ensure that there are design criteria against which new industry models will be measured and that such criteria include the elements important to the sustainable development of renewables.

Most of all, the renewables industry needs to understand the options available and develop a vision of politically feasible structures and policies needed to encourage renewables such as wind generation under various market models and actively participate in the restructuring debate *before* major changes are made. This is the time of maximum leverage after which it will be very difficult to influence the system.

Thoughts on the distributed utility and implications for India

Joseph Iannucci, Jim Eyer

Introduction

The DU (distributed utility) concept is a skillful integration of small generation and storage and DSM (demand-side management) into the distribution system of utilities. To be of maximum overall benefit, utilities should use these small elements (typically 500 kW to 5 MW) at overloaded distribution feeders. The feeders targeted should be those which have infrequent peak loads and/or are in areas with high upgrade costs. This includes areas which are currently unconnected to the grid, requiring an extension of transmission and/or distribution lines.

Figure 1 shows the present utility design compared to the distributed utility vision of the future. The central hub generation and spoke T & D (transmission and distribution) configuration, as shown on the left side of the figure, has been the typical pattern adopted by utilities to generate and distribute electrical energy. On the other hand, the DU structure has the central station power plants integrated with distributed DSM, generation and storage devices (right side of the figure). In some cases, utility-owned or operated modular generation technologies will serve remote loads that are currently too expensive to connect to the larger utility grid.

Using the DU concept, the central station assets are still likely to provide the majority of the energy needs of all customers, but the distributed elements will meet local feeder or customer peaks—*capacity* needs—when and where most useful.

Benefits of the DU structure are three-fold: improved utilization of the

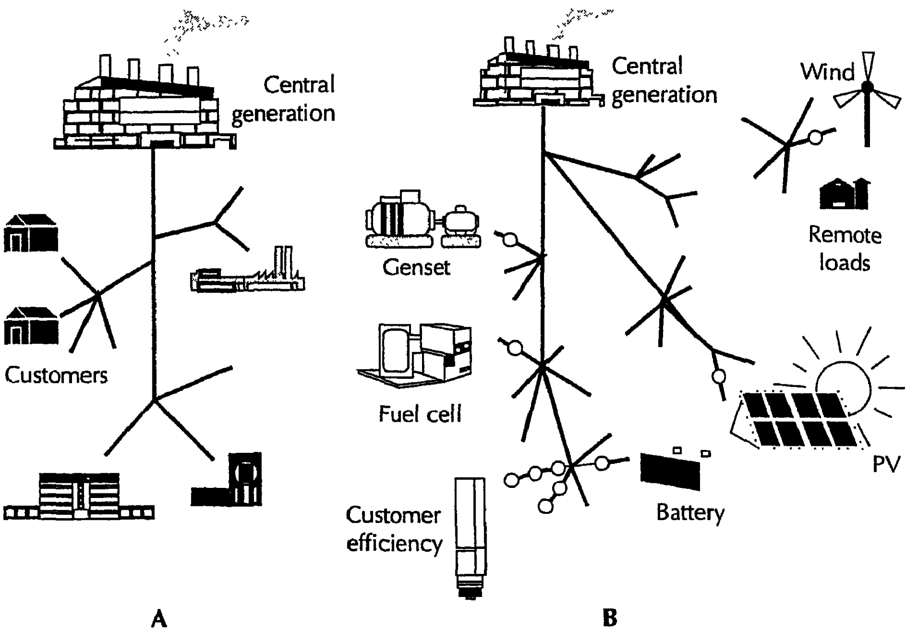


Figure 1. (A) Today's Central Utility; (B) Tomorrow's Distributed Utility

T & D systems, improved customer services (types and/or quality), and provision of utility-grade power for those off-grid.

Asset utilization

Under almost any regulatory structure, utilities will want to make the best use of capital and physical assets such as their T & D systems. Increasing costs, erosion of central station economies of scale, environmental considerations, increased competition, changes in capital investment patterns, and development of alternative technologies suggest that there are economic benefits to be achieved if DSM, modular generation or storage units are placed in the distribution system close to selected loads.

Further, because the T & D system is designed to meet infrequent but large peak loading, the assets that account for the major portion of the current and forecasted capital investment are not often utilized to capacity especially if expected load growth does not materialize.

In many cases the DU assets would only have to operate very few hours per year (e.g. less than 200 hours) to cut off the top 20% of the local peak. If low capital cost technologies are used (small engine-generator sets, time-

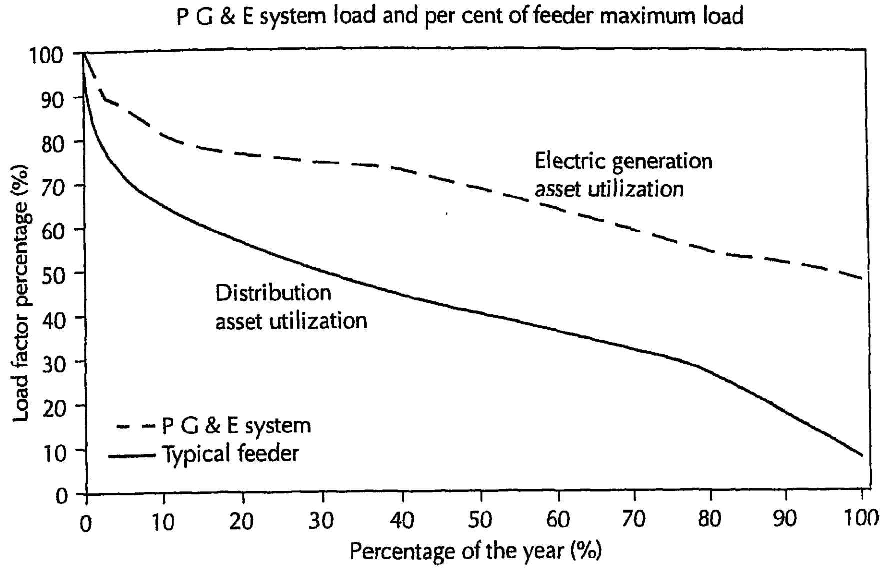


Figure 2. The Distributed Utility Opportunity: Improved Asset Utilization

of-use rates or DSM measures) this can be fairly inexpensive; portable generators are another attractive technology.

Expansion of the T & D system could be delayed (or avoided entirely) by such measures. Furthermore, T & D capacity can be upgraded in smaller increments, as the load grows, rather than making one large traditional T & D upgrade that is intended to address electrical load growth for many years. Such T & D upgrade deferrals may provide considerable financial benefits and reduce financial risk. With DU, less central generation capacity would be needed, so that the utility could move towards baseload utilization of both central generation and T & D assets.

If the forecasted T & D investments were small compared to the generation investment, relatively low T & D capacity utilization would not be an interesting issue. However, T & D investment is becoming the predominant capital cost item for the US utility industry as a whole. In 1989, the US capital investment in T & D systems equaled that in generation. This trend of increasing T & D investment and relatively low utility investment in generation is expected to continue (Electrical World's 'Forecast '92' indicates that the T & D share of the total utility construction outlays will increase to 80% by 1997).

The feeder load duration curves of the P G & E (Pacific Gas and Electric) system are shown in Figure 2. In the upper curve it can be seen that the generation assets are being used at 70% of capacity or more about 50% of the time. This is the accepted asset utilization by conventional utility standards. However, a typical feeder is being used at 70% capacity or above less than 10% of the time. Generation assets never fall below 50% utilization, while the typical feeder is utilized at 50% of capacity, less than 40% of the time. Thus the distribution system has a much worse asset utilization.

The difference between the utilization of generation versus that of the distribution assets occurs because feeder systems are sized to meet local area peak loads while the generation system must be sized to meet the entire system demand. Because the local area peak loads occur at different times throughout the system, they do not coincide at the time of system peak; the entire system demand will always be, in general, less sharply peaked than local area demand. Conversely, diversity effects moderate impacts from peak demand in specific areas as they affect the peak demand which the electricity supply system must meet.

Improved customer services

In order to compete, in the future a utility may have to provide differentiated services which address customers' needs at the lowest possible cost. In addition to requiring changes in planning procedures, assumptions and models, this will require operational changes.

Some expect that a utility's assets will have to be used more effectively to attract and keep the customers, by responding to customers' particular demands and not by simply providing a generic electric supply service. Utilities may provide energy efficiency services such as energy use audits, or they may sell the actual hardware required. High reliability/premium power quality electrical services can be provided by the use of generation or storage close to or at the customers' premises, for use during contingencies or when utility grid power quality diminishes. According to some experts, electric utilities will be collaborating or competing with local television cable companies to serve that market also.

Remote power

Some potential utility customers are too far from the existing grid to be economically connected to the system. Currently in the US, these customers are asked to estimate their likely loads so that the utility can calculate the revenues which will be obtained by serving them. Usually these revenues are overestimated by the utility but are still insufficient to economically expand the distribution system. These lost customers are left to identify and implement their own remote energy supply solutions.

The DU solution requires the utility to: (i) be willing to consider placing utility-owned generation, storage or DSM measures at the customer load and (ii) determine the revenue required to make that solution affordable and cost-effective for the customer and the utility. Temporary power, until local load grows or the grid expands closer to the customer, is another solution to be considered. Use of indigenous fuels such as renewables is always to be considered an option.

Evidence of the value of the DU concept

There is significant DU activity in the US; as of 1994 an estimated fifty utilities have performed DU studies or have installed hardware to test or apply the concept. The earliest studies of the DU theory were performed for more expensive advanced technologies in search of a market entry point: photovoltaics and fuel cells. Shortly thereafter, DSM studies began to attempt to leverage large expenditures in customer efficiency programs by claiming that customer energy efficiency and load management could achieve some of the same benefits that the distributed generation and storage advocates were finding. Traditionally benefits emphasized from customer energy efficiency and load management were related to reduced need for central/system energy and generation capacity.

Kerman

P G & E began a study of the use of photovoltaics in a grid-support application in 1989. The analysis considered using 500 kW of photovoltaics at a substation outside of the town of Kerman, near Fresno, California. The area had a slow load growth and a load shape which matched the solar production profile very well. Benefits of installing the photovoltaic plant were estimated to be up to $700 per kW per year, almost three times the value that would be estimated if the plant was evaluated from the traditional electric 'supply only' perspective. The P G & E and the DOE (Department of Electronics) installed the photovoltaic plant and they are currently measuring the energy, capacity, T & D deferral, reliability, voltage and VAR support benefits.

LADWP (Los Angeles Department of Water and Power)

The LADWP–EPRI (Electric Power Research Institute) performed a study of the benefits of installing fuel cells in dispersed locations within the LADWP service area. Similar to the Kerman PV plant the benefits of such installations were calculated to be well above the central station value.

Delta

Targeted use of CEE (customer energy efficiency) and DSM were examined in detail in a P G & E and EPRI study of P G & E's Delta district. The net value of deferring T & D upgrades with DSM (i.e. distribution planning area) has been determined to be tens of millions of dollars. The Delta results were used to design an extensive targeted DSM program which was successful in deferring impending T & D upgrades.

Others

Other technologies such as wind, standby generators, flywheels, superconducting magnetic energy storage, thermal (cool and heat) energy storage, and cogeneration (of electricity and heat for process, water, or space heating), etc. have been found to have significant potential to provide additional value if installed in the right places in distribution systems and when optimized to meet both the local and system-wide needs.

The DU in a restructured and competitive utility industry

All studies to date have evaluated the DU concept assuming rate of return regulation. While no one knows what form the utility industry or regulation thereof will take in the future, in the US or other countries, the current rules are likely to change dramatically, with significant implications for DU.

The most likely scenarios for restructuring include spinning off generation assets into a possibly unregulated arrangement requiring the utility to supply energy to any other utility or wholesale customer willing to pay its price. The transmission system may be independent, part of the generation system, or coupled with the distribution system. The distribution system is likely to be regulated (at least by the state) and allowed revenues will be determined by a performance-based ratemaking procedure indexed to the number of customers, fuel costs, inflation, etc.

How would the DU fare under such rules?

Although generation is moving toward greater deregulation, it is possible that the utility will retain a natural monopoly and obligation to serve in T & D. It may be appropriate to consider introducing distributed systems in the future. There fore, application of the DU concept aids utilities in fulfilling their obligation to provide T & D under the natural monopoly argument.

In more free market regulatory scenarios (such as total deregulation, retail wheeling to all customer classes, etc.), economically efficient planning and operation of the utility must be based on the total cost of electrical service, which includes the costs of all links between the power sources and the customer. If the DU is a basic economic advantage, someone, if not the utility, will find a way to profit from it. One example is retail wheeling, thought by some to be an unraveling of the fibre of the utility and hence a counter-indicator to DU. However, it may be that DU provides a means to offer more and/or better services to those customers or to expand their business by serving more customers. At the very least, the creation of area-specific marginal costs needed for DU planning is precisely what is needed for calculating retail wheeling access charges.

Even in a totally delaminated (generation, transmission, and distribution separated) utility, DU assets can serve a local distribution company to cut local peaks while providing excess power to wheel to customers outside of their franchise. What is important is not really who owns the DU assets, but whether there is a real economic driver for improved asset utilization and better/additional customer energy services and products. The risk and reward sharing between business functions which utilities now could perform, could be replaced by contractual relationships.

Starting over

What would the modern utility look like if it were to start over again today?

The utility world is far different from when it began a century ago.

- Economies of scale in very large central generation plants (e.g., coal, nuclear, and natural-gas-fired) can no longer be exploited to the degree that they once were.
- New competitive pressures on utilities will force them to become customer-driven, and either to become low cost suppliers or super service/value-added providers.
- The real marginal cost of additional T & D capacity has increased.
- Utilities are now under pressure to be environmentally sensitive.
- Real costs of alternative, modular, and renewable generation technologies are decreasing moderately and would decrease significantly if mass produced.

The emerging shape of the utility is dependent on the new regulatory rules, but certain questions need to be examined in any instance.

- Is it possible to serve customers at a lower cost and greater reliability with

a different planning approach instead of a major transmission system study and upgrade?
- Can the difficulties attendant to siting plant and transmission facilities be avoided by deferring these investments using alternative strategies and technologies to meet load growth?
- In addition to being technically feasible, are such alternative strategies economically superior?
- Is it possible to develop a planning process that can identify and evaluate such alternative strategies?

The answers to these questions will depend on the progress in development and commercialization of new technologies. A variety of new generation and storage technologies are approaching commercial viability for DU applications. Although the costs of these technologies (such as photovoltaics and fuel cells) have decreased only moderately, the potential for large cost reductions exists for most of them. Commercialization of these alternatives requires achievement of the economies of mass production to bring down their costs, and to improve their economics. This may entail the simultaneous evolution of markets and technologies.

The most viable DU alternative is the diesel engine generator set (diesel genset). These are proven and reliable, inexpensive to purchase, and can be supported by indigenous industries. The downside, of course, is the use of expensive fuel, high O & M (operation and maintenance) costs, noise, and pollution. However, these negatives can be offset if the genset is used only for very high value DU applications which require operation for a small portion of the year. Also, waste heat from gensets operated for extended periods can be used for process heat for industrial, agricultural, water, or space heating applications. Advance versions can be operated on clean burning natural gas or biogas.

Many distributed generation technologies, such as photovoltaics, solar thermal, wind, cogeneration and fuel cells, are viewed as more environmentally benign than central station alternatives. The green movement that began in the 1970s is a force that regulatory bodies and utilities will surely have to consider as they plan the evolution of their systems.

It is possible that the utility of the future will derive its most important planning data from the power distribution at the substation level and customer sites. Planners will benefit from information fed to them on customer mix, demand and consumption by customer type, outage history, and the customer's value of reliable service. Planning models that address these issues do not exist currently.

The confluence of all of these—technology, regulatory, business, and planning drivers—and the uncertainty of making large investments for an uncertain future leads one to think on small, distributed, modular and incremental lines. The DU vision of the utility of the future best incorporates these features.

DU for developing economies

Developing economies have exciting opportunities to use the DU concept as a step toward further grid connection without immediate investment in transmission facilities.

Fully developed and integrated modern utilities come to the DU concept as a way to improve the asset utilization of existing T & D systems. In areas without a grid connection, development of the local utility can begin with distributed generation, cogeneration, storage, and customer energy efficiency. The grid connection can be effected once the local load has grown to the point of affording or requiring the transmission connection. Less developed electrical grids, such as those with unreliable grid interconnections or distribution feeders can use DU alternatives to increase reliability and/or improve power quality. This would reduce customer downtime and thus increase productivity and commercial viability.

The strongest indicators of the viability of DU in the developing countries would be high marginal T & D costs, relatively dispersed loads with many villages still unconnected, high T & D energy losses (both technical losses and theft), rapid electricity demand growth, unreliable utility interconnections or poor local power quality.

The interim period should be managed by a local or municipal utility which can assist the customers to adopt energy efficiency and local renewable resources. Renewables such as biomass, photovoltaics and wind (especially with storage) can provide energy supply, autonomy, and local electric peaking capacity. Hybridized systems with renewables, storage and a small engine generator set can become modular 'mini-utilities', which are fully capable of meeting local needs with modern technologies.

This phased approach to grid interconnection avoids the immediate costs of transmission, but encourages a local utility to serve local customers. The DU assets installed in this first phase are not wasted once transmission is accessible, rather it would serve as a grid-support and a localized load-leveling function once full grid integration occurs. The transmission service will be more economically justified once local loads have grown to supply the revenues required to return the transmission investment to its owners. When the transmission connection is accomplished, the grid will look just like a modern integrated DU. In some developing countries the potential market for such grid-support and application of renewables can be immense.

Necessary conditions for the DU

For the DU concept to make sense, the utility (or electric service provider) must assume a more holistic planning and operation approach. If individual utility departments (for example, a single planning organization) make investment decisions without considering their impact on other departments, the DU is likely to fail. Risk and reward sharing is very important.

All engineering alternatives should be evaluated with respect to their effects on the entire system. In particular, the cost of implementing distributed technologies at the local level, as an alternative to other expansion plans, should be compared to all costs avoided by such implementation. These avoided costs, which will almost surely vary by location, include the combined avoided costs of generation, transmission and distribution. Utilities may choose to dispatch DU assets for local needs alone, or optimize the dispatch for both local and system-wide economies. This is especially important for storage technologies and for fossil technologies which may have environmental dispatch limitations.

An appreciable amount of data is needed to support a planning methodology for the DU. The nature of interrelationships and interdependencies among all the elements, stakeholder and activities in the distribution system must be understood to ensure success in engineering, planning, implementation and operation. Local area load forecasting must be done accurately.

The DU technologies (generation, storage, and DSM) must be ready, with regard to price, O & M costs, reliability, ease of maintenance, size/footprint, etc. Efficiency or heat rate are not as important as low installed cost due to the few hours of operations expected per year. Enabling technologies such as sensors, communications and controls must be available and affordable for a deep penetration of the DU into a utility system.

Institutional freedom must be obtained from all the stakeholders (regulators, governments, etc.) to pursue the DU vision. For example, micromanagement of distribution decisions (such as the installation of DU assets to defer distribution investments) by regulators will add costs, complexity and confusion.

Finally, utilities must realize that their customers are really in charge of their own destiny. The utility restructuring occurring in the US is just the beginning of customers (large and small) realizing that they can and will have viable energy supply options. These customer needs will be met by the current utilities or some other energy service supplier more amenable to meeting those needs. The DU may be an important part of that new service paradigm.

Prospects for DU in India

Prospective DU applications in India

Several obvious benefits and applications for DU have been discussed at length; improved prospects for economic expansion of the electrical grid, improved commercial/economic viability of local industries, improved quality of life, increased use of indigenous technology and energy resources, and others.

Probably the most important grid connected applications of DU for India in the near term are: (i) system upgrade deferrals for specific T & D projects; and (ii) improvement of local power quality/reliability. The first application has been described above at length. The other involves the use of DU technologies to provide significant help in situations where the energy supply is reliable but where customer systems cannot operate reliably due to moderate-to-significant power quality problems. Lead–acid batteries or diesel gensets, coupled with sophisticated but cost-effective power electronics, could provide significant improvement in this regard, at a relatively low cost. Battery and genset systems can address problems related to voltage sags, underfrequency conditions, current harmonics, and reactive power using very little energy. Because of their modularity, these solutions can be tailored and optimized for specific loads/needs.

In addition to being an alternative to expensive, often unlikely electrical system(s) upgrades, once installed these systems could be used for other applications such as load leveling or for emergency backup power for critical loads. Leveraging such synergies may be critical to render any given project economical.

Institutional enablers for or complimentary to DU in India

Utilities need a better understanding of their costs. One key reason why DU has not been considered as an alternative in the past is that utilities do not have a good understanding of the costs which could be influenced by DU alternatives. In the past, rates based on revenue requirements (as opposed to those based on profit and cost) only required the utility to know total costs. But, the new utility marketplace will require utilities to know their costs better. This will make it much easier to: (i) identify opportunities; and (ii) to evaluate the merits of DU more fully and credibly than was possible before.

Tariffs should encourage economically efficient use of and additions to electricity systems. Possibly the most important action which India can take as its electric system grows is to establish an electricity tariff framework which encourages customers to make the most economical use of all electricity systems. Effective tariffs are needed to make the greatest number of prospective electric service expansion projects viable, especially those involving DU.

To be effective, tariffs must: (i) be consistent with costs, system-wide and local, average and incremental; and (ii) send price signals which result in electricity supply (utility and independent) and uses that optimize benefits. As described below, it is also important for those planning and designing electrical systems to consider all stakeholders' perspectives and to integrate planning for separate elements of the electric system, i.e. generation, transmission, distribution and service delivery.

Despite the added complexity; for energy users, utility customer service providers and planners, and independent power and energy services providers, this is the most efficacious way to optimize benefits to all. Users get new service where none existed before, or they get improved power quality or reliability on existing systems, both at the lowest price possible. Those who provide power or energy services benefit by reducing uncertainty about revenues from their investment and by developing new opportunities to provide value-added (higher margin) energy services and new products to new and existing customers.

For existing systems such cost-based tariffs provide additional and more certain resources (revenue) with which to improve service quality. For new installations it makes the enterprise more attractive economically, by expediting amortization of the investment. Specifically:

- tariffs should include *demand* (true power requirements measured in volt-amperes) and *time of use* energy charges to encourage high, levelized asset utilization;
- tariffs for commercial customers should account for PQ (power quality) impacts from customer loads. This increases electric system capacity, reduces electric system energy losses, and improves user productivity by reducing downtime. Volt-ampere metering is one way to address this problem; and
- *current cutouts* on customer electric service could be used to limit peak demand on system(s) in return for reduced energy prices.

Establish planning, capital budgeting, and power procurement (bidding) frameworks that enable stakeholder participation and consideration of all perspectives and alternatives.

- Power users/customers;
- Affected residents;
- Electricity generators (generation companies, GENCOs);
- Electricity transporters (transmission companies, TRANSCOs);
- Electricity distributors (distribution companies, DISCOs);
- Electricity services providers (energy services companies, ESCOs);
- Fuel providers;
- Equipment vendors;
- Environmental groups; and
- State and federal governments/regulators.

The inclusion of stakeholders, integrating planning and capital budgeting for electricity systems addresses several issues and opportunities.

Firstly, more solutions are considered, reducing the chance that better solutions are not evaluated. Secondly, such a process may identify otherwise unknown synergies among several components comprising an alternative solution and/or opportunities to aggregate many small needs to make a large opportunity with additional prospective solutions. For example, the local engine vendor could work with his customer and the local utility so they share the customer's new backup generator. The utility could get low incremental cost electricity generation capacity while the customer offsets the cost for the backup generator. Thirdly, risks and rewards for optimizing the system will be more explicit and hopefully will be allocated more effectively and fairly.

Establish a rationale, framework, tools and information for evaluating DU alternatives. There is a need to establish means to perform fair and credible evaluations that include distributed generation, storage, DSM and customer energy efficiency as alternatives to any purely generation, transmission, or distribution expansion or upgrade project.

Develop standardized modular systems. Systems would be designed for easy construction, upgrading, dismantling and transport (usually requiring trucks) and as products that could be produced by an indigenous industry.

Enable local cooperatives to establish power services. Cooperatives may be grid-connected, to-be-connected, or unconnected service for a region, town or village. Hundreds of these cooperatives exist in the US and elsewhere, for all types of utilities. Users-as-owners tend to be more ardent about prudent development of systems based on need, and making the most economical use of assets.

Promote the use of new low wattage electric cooking appliances. This has good prospects for reducing the use of traditional fuels especially wood, and to encourage electric system asset utilization. It could also provide an indigenous industry for India.

Further thoughts on distributed utilities

Joseph Iannucci, Jim Eyer

One DU (distributed utility) demonstration or pilot project should be implemented by each state utility that includes adaptation of analytical tools and staff training

It is difficult to comment on this recommendation specifically given our limited understanding of the sizes, roles, responsibilities, capabilities, and politics of states and their relationship with utilities in India. However, in general it is difficult to make demonstrations of the DU concept very generalizable. Therefore, before pursuing a program to demonstrate DU resources, a clear understanding of the objectives for such a program is needed.

It may be more desirable to establish national or regional assistance centers which *enable* consideration and use of DU by:

1. serving as a central repository or clearing house for information and technical expertise;
2. developing, demonstrating, and transferring DU technology (equipment, as opposed to applications);
3. providing assistance and guidance regarding DU evaluation techniques and tools; and
4. providing assistance with (i) stakeholder integration, (ii) benefit evaluation, (iii) benefit aggregation, and (iv) cutting red tape.

Such an entity would serve as a resource, rather than a key validation of the DU concept. One model is the Sandia National Laboratory Photovoltaics Design Assistance Center in the US.

Furthermore, to avoid 'negative' results that could taint people's opinions about prospects for DU in general or for any DU alternative, *demonstrations* should be limited to efforts to show the *technical viability* of a specific DU technology or concept or to test important hypotheses related to a given technology or application. By contrast, *pilot* projects intended to show *commercial viability* should be limited to those which: (i) are based on actual project economics; (ii) have limited technical risk—mostly familiar techniques, tools, and equipment, but in novel ways; and (iii) are not likely to succumb to institutional factors.

State utilities, the National Thermal Power Corporation, and the Power Grid Corporation (completing the national transmission grid) should not receive approval for generation, transmission, or distribution system expansion without having identified and analyzed the cost-effectiveness of DU opportunities

We believe that it behooves utilities to begin to consider all plausible alternatives, including the DU, when attempting to identify preferred and/or optimal solutions. Initially this may only be feasible for specific situations, for individual projects requiring significant amounts of generation, transmission, or distribution capacity, or a combination of these. Such *project-specific* evaluations would require some training for utility distribution engineers and service planners, and adaptation of engineering economics and systems planning tools and methodologies to include cost, performance, and benefits attributable to the DU resources.

It will be much more difficult to incorporate the DU into *central* capacity approval processes for utility systems (generation and transmission). The potential and expected size of the DU resource—as aggregate resource blocks—is what affects the central capacity planning with regard to the DU. Before that can be evaluated, planners need an improved understanding of the *market potential* for and realistic high level estimates of the DU market penetration (i.e. electrical energy and capacity provided). This requires an evaluation of the size, likelihood, number, timing and possibly the location of prospective DU projects.

One way to arrive at a gross estimate of the potential system-wide impacts of the DU would be to undertake 'statistical' evaluations of market penetration. Criteria and techniques mentioned above for project-specific evaluations would be used for representative projects. Estimates of the total capacity and energy provided by the DU, if any, are made on the representative projects' gross economics and based on estimates of the number of the representative projects in the service area. This is similar to projections used to estimate penetration and persistence of energy efficiency.

Central evaluations may also include some technical evaluation of power distribution systems. These are needed: (i) to identify high marginal cost areas within the grid for which the DU could be a solution; and (ii) to determine technical limits to DU penetration.

As knowledge and experience are gained and as evaluation techniques improve, market estimates can be refined, which in turn will improve the central planning estimates of the DU impacts.

Private power developers should contribute to a fund (whose purpose is) to identify DU applications

Requiring an entity to participate in collaborative R & D, while leveraging scarce R & D funds and increasing technology transfer, is most likely to be counterproductive. Such a fund could stifle competitive incentive to produce the highest value or most innovative DU solutions. Furthermore, these required collaborations often become mired by sociological tinkering, and political and other marginally relevant agendas.

Conversely, the present and prospective DU products and services providers, especially smaller ones, may want/need to establish collaborative R & D to scope, demonstrate, and evaluate the DU technologies and evaluation tools and techniques. This is especially important for smaller developers who need the greatest possible leverage for 'research' funds spent. Perhaps this could be part of a trade organization or assistance center described above which would also address political, institutional and other common issues, and seek to develop and nurture complimentary and synergistic business relationships needed to make DU solutions viable.

State utilities should be encouraged to contract with energy service companies who would provide DU services

Again, requiring state utilities to adopt the DU concept would probably be counterproductive. The preferred option is to give the customer the choice and allow the marketplace to develop products and services required. In some cases the best vendor (energy services provider) may actually be the local power distribution company itself. It could also be any of the following, depending on strengths, weaknesses, location, business focus and strategy of each entity: (i) a competing power distribution company in another geographic area; (ii) a non-utility vendor that packages others' energy/power, energy services, and energy products for sale (iii) a non-utility vendor that packages its own and/or others' energy/power, energy services, and energy products for sale; or (iv) a utility/non-utility vendor relationship.

Appropriate Central government ministries should develop a phased DU program that defines appropriate pilots, identifies financing approaches, proposes aggregated deployment programs, identifies institutional incentives and barriers, and seeks technical assistance from the US and financial support from the World Bank and other lending institutions

This seems like an excellent idea. However, government agencies should attempt to provide a catalyst as opposed to a leadership role. They should be involved as a key stakeholder and/or partner. Private sector and utility members of a Stakeholders Oversight Committee should be encouraged to lead the process, with government officials as partners and enablers. Members of the committee should include representatives of all key stakeholders: politicians, government agencies, regulators, utilities, planners, customers, neighbors, competitors, partners, the financial community, technologists, and environmentalists.

Emphases should be in order of priority: (i) information gathering and sharing; (ii) institutional barrier reduction such as onerous permitting and barriers to competition; (iii) enabling financing by advocacy within the domestic and international financial communities, and by removing any domestic legal impediments to financing; and (iv) coordinating among domestic R D & D (research, development, and demonstration) programs and projects, for financial leverage of DU evaluation and technology R D & D, and to sponsor assistance centers similar to the Sandia National Laboratory's Photovoltaic Design Assistance Center.

Comments on the report entitled 'Benefits of Targeted Grid Support Photovoltaic Systems in India' by Dan Shugar

General

Overall the study seems to be complete and credible. In general the analysis seems to be fairly thorough, and given the resource constraints for the work, the criteria evaluated and the techniques used seem appropriate. The cost data in particular (still) seem quite reasonable; benefit values also seem reasonable, however, as Shugar points out in the document, benefits are much more problematic, and often more contentious, to quantify. He also notes correctly that some key benefits require much more rigorous evaluation and discussion. In addition, evaluating the relative value of PV systems and their alternatives often requires participation of a broad array of stakeholders including politicians, government agencies, regulators, utilities, planners, customers, neighbors, competitors, partners, the financial community, technologists, and environmentalists.

Methodology

The economics of off-grid applications in general is affected more significantly by distance from the grid than indicated in the report. Relative economics of diesel engine pumping and PV may also be affected more heavily than indicated in the report by geographic differences in distance to sources, price, and availability of diesel.

Benefits

With regard to benefits of distributed generation in general; since Shugar completed this work, it has become apparent (in the US) that deferring (and in the best cases, avoiding entirely) upgrades to existing T & D systems is a significant benefit. In many prospective cases for which distributed generation is being evaluated, this is the most significant component of total benefits. This is especially true for utilities with high capital cost.

Other less explicit benefits accrue because of the ability to add smaller increments to the electricity infrastructure. These benefits relate to increased asset utilization and more efficient use of scarce capital achievable by adding distributed generation and storage in increments. Specifically, benefits include: (i) avoided unutilized capacity—capacity that would otherwise have to be built into the T & D system to accommodate growth (i.e. utilities cannot add a little bit of T & D as needed); (ii) reduced risk that assets will become stranded if expected load growth does not occur; (iii) increased load factor (increased revenues for each dollar of infrastructure investment) for existing or complementary new assets; and (iv) benefits derived by use of freed up capital.

Another important benefit is that there is reduced risk that a useful solution will not be used. If a small, modular solution does not work or if it is satisfactory for less time than expected, a more robust solution (a T & D upgrade, for example) can be implemented and the modular equipment can be redeployed at another location. Furthermore, unlike traditional T & D, modular generation systems can be evaluated for projects with time horizons which are much shorter than the equipment's actual life, with a credit for remaining useful after relocation.

No matter what the technology or resource, valuation of economic development benefits will be an increasingly important driver for these types of projects:

- paramount are prospects for the creation of more jobs—(i) *directly for* the project, and (ii) *enabled by* the project
- creation of new businesses and industries
- improved power reliability and/or power quality that enables new enterprises and/or industries
- increased tax revenues
- increased use of, efficient production of, or value-added to agricultural products that otherwise face reduced competitiveness and/or declining markets.

In the US, the energy diversity benefits of solar energy, while seemingly important in concept and in political arenas, often takes on less significance in practice when it comes to monetarizing and allocating the resulting price increment, and when evaluating the relatively small contribution it can make in the foreseeable future. Unless specific costs are quantified, such as military expenses attributable to keeping supplies secure, these benefits often end up being contentious.

Conclusion

As Shugar notes, PV should be considered as one of several alternatives for the types of situations described in the Report. For the record, the following are some of the more obvious alternatives, including those listed by Shugar. These are, or will all be, feasible using a rapidly expanding array of power electronics, computer, mass-produced modular generation and energy storage technologies, and mass-produced energy efficient equipment (especially lighting, pumps, and motors).

- energy efficiency
  - lighting
  - industrial/commercial motors
  - pumps
- optimized T & D operations
  - distribution automation

  - dynamic thermal rating
  - voltage stabilization
  - improved VAR control/pricing
- direct load control
- on-site energy/demand management
- battery-only (provides UPS *and* load leveling)
- battery/diesel generator-set hybrids (provides UPS *and* load leveling)
- partnerships with owners of existing non-utility capacity (utility dispatchable distributed generation or storage)
- solar thermal hot water and/or low grade process heat
- solar thermal dish stirling
- solar cookers
- natural gas-fired or propane-fired engines
- cogeneration
- innovative electricity tariffs
  - tiered
  - time-of-use
  - curtailable
  - interruptable

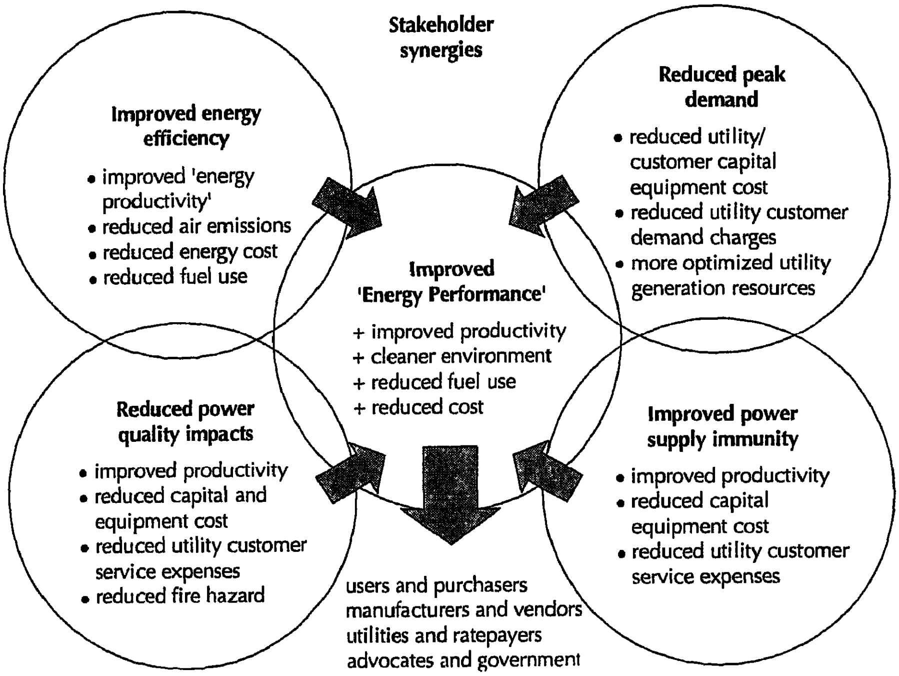
and over the longer term,

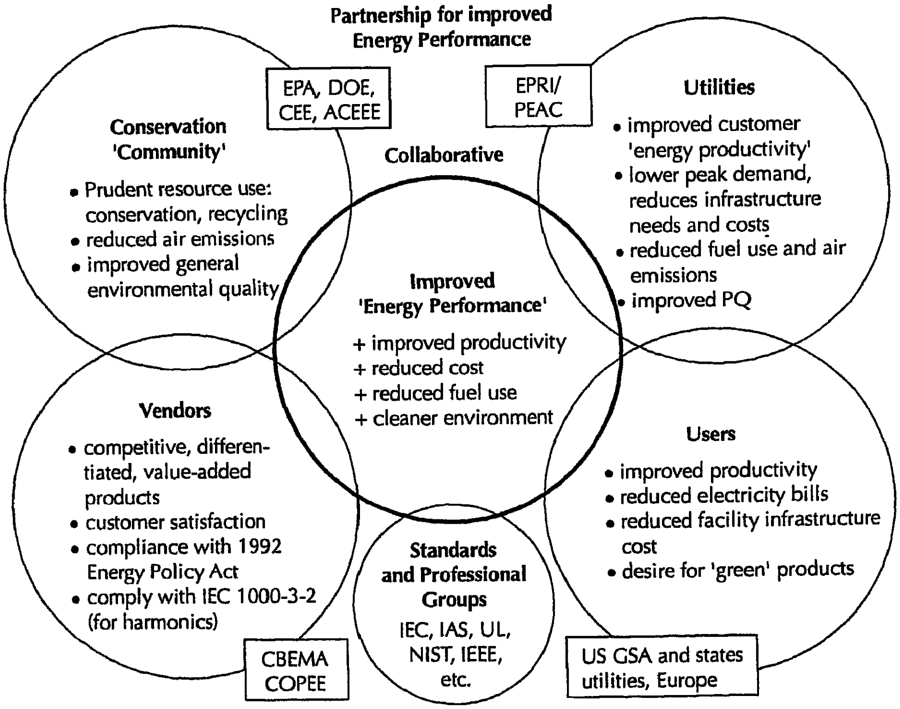
- supercapacitors
- advanced batteries
- small coal/biomass gasification with engine or turbine generators

While it would be prohibitive to evaluate all types and combinations of these alternatives, for the study or real applications, care should be given while eliminating any of them for grid-connected applications. We recommend that a screening evaluation be performed, perhaps one similar to that performed by Shugar for PV, for the other plausible alternatives, especially DSM, energy efficiency, engine generator-sets, and batteries. (This assumes that an overarching objective of program(s) you are considering would be the identification of optimal alternatives in any given situation, rather than to validate or demonstrate the PV alternative.)

An alternative to building the PV systems immediately would be to develop power plant production and cost profiles, and model the effect of the leading alternatives that passed the screening process described above on the technical and economic performance of the grid. This would allow the program to focus on a broad, flexible portfolio of solutions for the increasingly diverse needs and demands of the evolving electricity marketplace.

In conclusion, the results seem to indicate good prospects for the DU in general in India. The most economically efficient (but naively idealistic) ap-


Stakeholder synergies
Improved energy efficiency
• improved 'energy productivity'
• reduced air emissions
• reduced energy cost
• reduced fuel use
Reduced peak demand
• reduced utility/ customer capital equipment cost
• reduced utility customer demand charges
• more optimized utility generation resources
Improved 'Energy Performance'
+ improved productivity
+ cleaner environment
+ reduced fuel use
+ reduced cost
Reduced power quality impacts
• improved productivity
• reduced capital and equipment cost
• reduced utility customer service expenses
• reduced fire hazard
Improved power supply immunity
• improved productivity
• reduced capital equipment cost
• reduced utility customer service expenses
users and purchasers
manufacturers and vendors
utilities and ratepayers
advocates and government


Partnership for improved Energy Performance
EPA, DOE, CEE, ACEEE
EPRI/ PEAC
Collaborative
Conservation 'Community'
• Prudent resource use: conservation, recycling
• reduced air emissions
• improved general environmental quality
Utilities
• improved customer 'energy productivity'
• lower peak demand, reduces infrastructure needs and costs
• reduced fuel use and air emissions
• improved PQ
Improved 'Energy Performance'
+ improved productivity
+ reduced cost
+ reduced fuel use
+ cleaner environment
Vendors
• competitive, differentiated, value-added products
• customer satisfaction
• compliance with 1992 Energy Policy Act
• comply with IEC 1000-3-2 (for harmonics)
Users
• improved productivity
• reduced electricity bills
• reduced facility infrastructure cost
• desire for 'green' products
Standards and Professional Groups
IEC, IAS, UL, NIST, IEEE, etc.
CBEMA COPEE
US GSA and states utilities, Europe

proach to accelerate the adoption of the DU concept would be to encourage Indian utilities to: (i) know and account for all of their costs; and (ii) provide the means—voluntary pricing mechanisms reflecting desegregated costs—that any electricity consumer can use to optimize solutions for their own needs. If users are able to internalize some of the benefits accruing to the utility from the DU through pricing or other economic means, the marketplace is likely to sort things out as well as or better than most demonstration programs or well-crafted regulations.

Stakeholder synergies and partnership benefits are given in the two charts.

Distributed power generation

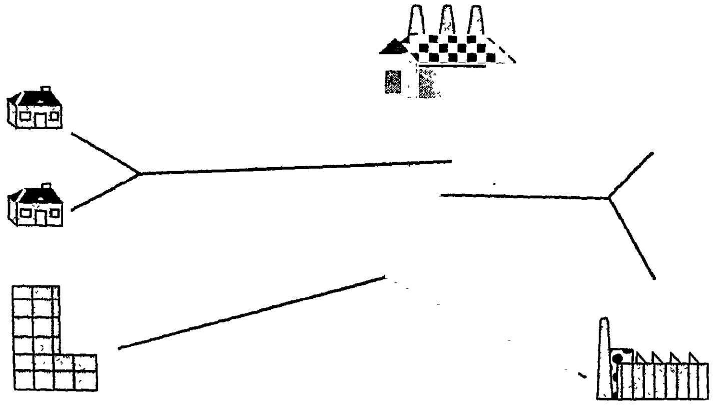
Pascal De Laquil

Today's energy situation

- Growing demand for power.
- Chronic power shortages and energy inefficiencies.
- Rising environmental concerns.
- Massive urbanization.
- Capital shortfalls for mega projects.

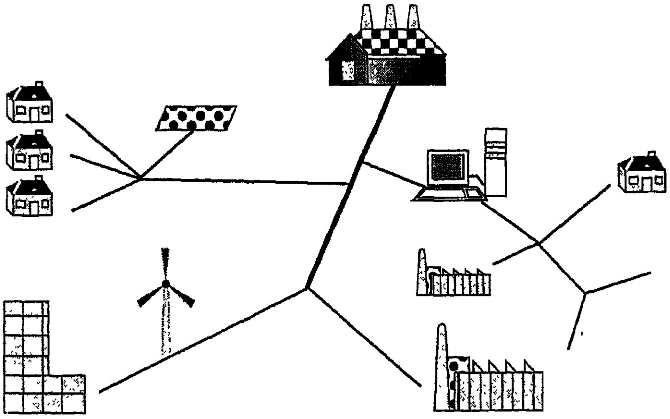
Traditional utility model

- Central Station power plants.
- Major T & D (transmission and distribution) infrastructure.
- Centralized control.



Distributed utility model

- Multiple modular power plants.
- Minimum connect costs through sub-grids and mini-grids.
- Network control.



Distributed generation benefits

- Save capital.
  - Reduced generation requirements
  - Deferred T&D upgrades and new construction
- Save energy.
  - Reduced transmission losses
  - Less theft
- Save the environment.
  - Increased efficiency
  - Cleaner technologies

System benefits

- Improved reliability.
- Improved power quality.
- Voltage support.
- VAR support.
- Control flexibility.

Distributed generation

- Integrates strategically deployed modular systems with central station plants.
- Provides energy delivery and control value to existing grids.
- Can provide electric power to rural areas more quickly and cheaply.
- Technology choices are determined using least-cost planning methods.
- This approach is gaining growing acceptance across the USA.

Activities in the US

- Thirty-one states have adopted integrated resource planning.
- Cooperative utility groups.
  - UPVG (Utility PhotoVoltaic Group)
  - UBECA (Utility Biomass Energy Commercialization Association)
  - Fuel Cell Consortium
- Many distributed generation demonstrations.

Projects in the US

- Ignacio Generator Set project: P G & E (Pacific Gas and Electric)
  - 1 MW gas engine
- Hedge Substation project: SMUD (Sacramento Municipal Utility District)
  - 200 kW photovoltaics
- Chino Battery Plant: SCE (Southern California Edison)
  - 10 MW/4 HR lead–acid battery
- Carbonate Fuel Plant: Santa Clara
  - 2 MW MCFC (Molten Carbonate Fuel Cell)
- Modular Biomass Plant: TVA (Tennessee Valley Authority)
  - 200 kW Fluidized Bed Combustion Turbine

Distributed generation in India

In cooperation with interested SEBs (state electricity boards), define and develop distributed generation programs which can be implemented and evaluated as pilot projects that lead directly to large-scale aggregated projects.

Distributed generation program

- *Phase 1*: Program definition and feasibility study.
- *Phase 2*: Pilot program implementation and evaluation.
- *Phase 3*: Aggregated program implementation.

Phase 1: Feasibility study outline

- Define distributed generation pilot programs.
- Develop integrated resource planning methods.
- Identity system improvements.
- Develop program evaluation measures and targets.
- Identify financing approaches.
- Define aggregated deployment programs for distributed generating systems.
- Identify institutional and financial barriers.
- Develop implementation plans and incentives.

Program funding

- Seek technical and funding supports from US DOE (Department of Energy), AID (Agency for International Development), and MNES (Ministry of Non-conventional Energy Sources).
- Seek implementation financing support from the World Bank and others.

Commercialization of bio-energy

B C Jain

Potential dangers

- Unsustainable over-exploitation for profit-making.
- Deprivation for the poorest of the poor..
- Potential loss of soil nutrients.
- Promotion of immature technologies.

Some constraints

- Diverse biomass resources and possible biomass-specificity of technologies and devices.
- Low energy density and large bulk.
- Seasonality, particularly in case of agricultural residues.
- Localized price sensitivity due to relatively high cost of transportation; associated vulnerability of bio-energy projects.
- Perception of 'bio-resources' as traditional (low-tech) fuels.

Commercial enterprises in bio-energy—major challenges

- Increasing efficiency of utilization of currently used bio-resources.
- Developing and propagating technologies for cost-effective and efficient conversion of bio-resources to fuels, energy and power.
- Intelligent and economic production of bio-resources from available waste lands, thereby significantly enhancing bio-resource supply for energy purposes.

Current role of commercial enterprises in India

- Traditional roles generally dealing with trading in firewood, etc.
- Recent developments relating to biogas, improved cookstoves and briquetting.
- Increasing presence and the role of medium and large enterprises in co-generation (e.g. sugar mills), generation of energy from industrial effluents and municipal sewage, etc. (in addition to the general area of briquetting).
- Likely increased presence in areas dealing with fuel, energy and electricity production from bio-resources.

Possible role for commercial enterprises

- Developers and providers of requisite technology and hardware.
- Promoters of large scale bio-resource use.
- Motivators for large scale bio-resource production.
- Providers of requisite support services to ensure long-term success of technology and devices (turnkey project implementation, after-sales service, system operation and maintenance, etc.

Combined power and heat in decentralized power systems: the untapped megawatts

P K Sen

We are in a unique situation at this point of time when a very large area of opportunity has opened up in India in the form of decentralized power systems. With the present liberalized environment, many options are available to harness energy in fuel more efficiently to generate power as well as use the remaining heat in the fuel, which can give an efficiency utilization of nearly 90% as against a maximum of 34% in the conventional rankine cycle power system. The concept of cogeneration, taken to its logical conclusion in the decentralized power systems, promises enormous benefits.

Cogeneration simply means simultaneous generation of thermal and electrical energy. The US has done some pioneering work in the area of cogeneration, both on technology and on developing a suitable legal framework, which makes it possible for small producers to generate power and sell it to the utilities at a price where everybody wins. It is estimated that some 60 000 MW of power is generated in the US by small producers and sold to the utilities.

In a path-breaking study done in 1990 by the Bureau of Science and Technology of the USAID (US Agency for International Development), it was estimated that the potential for cogeneration in India is estimated at around 10 700 MW. These include sugar, edible oil, food processing, rubber, paper and pulp, refineries, fertilizers, polyester, petrochemicals, etc. All these industries lend themselves to cogeneration, i.e. the same energy input can be used for generating power and steam, making the industry self-sufficient. But if the steam can be generated at much higher pressures, each one of these industries has a potential to generate exportable power.

Now that fuels like naphtha are available at very reasonable prices, gas turbine-led cogeneration systems offer a lucrative option. For a typical average-sized polyester plant, approximately 27 MW could be generated and by combining the heat energy generated by the process including vapor absorption cooling, the overall utilization of energy is at the level of 88%. Economically, this offers a payback of less than three years.

I would like to concentrate on one special aspect of the decentralized power systems, namely, the cogeneration scenario in the sugar industry, which currently has significant relevance in India.

India is the largest producer of sugarcane in the world. Over the last few years, the annual sugarcane production has been around 222 million tonnes. Of this, approximately 50% (i.e. 111 million tonnes) is crushed in sugar factories and the corresponding sugar production is approximately 10 million tonnes, which is the highest in the world. Sugar accounts for about 15% of India's agricultural output in value from only 2% of the cultivated area.

About three years ago, I was invited to a Conference in Hawaii organized by the Winrock International on Energy from Sugarcane. The Conference was an eye-opener as we learnt that 70% of the electrical energy demand of Hawaii was met from power generated by the sugar factories, and in the Reunion Island, 60 MW of export to the grid was planned by a single sugar factory. During this Conference, Thermax took the initiative to encourage USAID/Winrock to undertake site-specific studies to identify bankable cogeneration projects in India. The study was carried out in three mills, two in Tamil Nadu and one in Maharashtra, and revealed that all the mills could be reconfigured to export power. The amounts depend upon the size of the mill, the choice of the cogenerating scheme, and the availability of additional fuel to supplement bagasse produced on site. The maximum output that would be available for export from each of the mills is:

Electric power generation for export

Mill	Crop Season (MW)	Off-Season (MW)
6000 TCD (tonnes crushed per day) mill in Tamil Nadu with dual-fuel	34	51
4500 TCD mill in Tamil Nadu with dual-fuel	18	24
5000 TCD mill in Maharashtra (bagasse only)	12	17

Generating power economically for export will require the installation of double extraction condensing turbines and boilers capable of producing steam at 63 ata and 480 °C. This will be a departure from the conventional industrial practice in India. Some concerns were expressed on the operation of high pressure boilers in the sugar mills (63 ata in place of 21 ata) but this is not valid in India, as a large number of industrial boilers are operating at 63 ata or above and it is clearly established that with proper feed water control, boiler operation at this pressure does not present any problems. The added risk of contamination of feed water by sugarcane juice can be effectively eliminated by exercising proper control.

It is interesting to reflect on the performance of countries which generate electric power from sugarcane. In Hawaii, the average is 70–80 kWh per tonne of cane and in Reunion, the industries are gearing themselves up to produce 100 kWh per tonne of cane.

With a higher pressure and temperature configuration of the boiler units, 100 kWh per tonne of cane is easily obtainable in India and the potential of 3000 MW from sugar cogeneration alone is definitely possible.

Economic viability is highly sensitive to the amount of power exported per unit of capital investment and thus depends upon year-round operation, with supplemental fuels during the off-season, and a large generating capacity relative to the internal electrical demands of the mill. Reduction in process steam requirements from over 500 kg down to 400 kg per tonne of cane, by adopting measures for energy economy and conservation makes additional amounts of bagasse available for off-season power generation and helps towards year-round operation.

Though the technology on cogeneration has been well known for many years, it alone is not enough to make a cogeneration project successful. Other issues like equitable power purchase contracts, application of avoided cost methodology for arriving at reasonable power tariffs, SEB regulations/ wheeling and banking/payments by SEB, etc., had to be addressed. These issues are common to all cogeneration projects and are not specific to the sugar industry. In this context, the USAID/Winrock took a very positive step in funding for experts in the related fields who interacted with the sugar mills, utilities, and government bodies connected with the study.

The findings of this study convinced the Tamil Nadu government authorities to look at sugar cogeneration from a different perspective and this led to their offering a meaningful composite package to the sugar cogenerator within six months of presentation by the USAID. Broadly, the package offered to the cogenerator is: (i) purchase of electricity at the high tension consumer rates less transmission costs; (ii) assurance of payments by the SEBs within 30 days, failing which interest-related compensations are given; and (iii) allow wheeling and banking arrangements with clearly specified charges.

This has helped the industry significantly and led to the finalization of a 19 MW cogeneration project in a private sugar mill in Tamil Nadu where the study was made. Tamil Nadu has the special advantage of utilizing lignite with sugar cane residue in a dual-fuel mode and a number of projects in the range of 30–60 MW are on the anvil and nearing finalization.

The MNES (Ministry of Non-conventional Energy Sources) recognizes the benefits and has taken up promotion of sugar-based cogeneration on a national scale. The MNES has now offered significant incentive packages which would trigger a boom in sugar cogeneration in all sugar-producing states.

Up to this time, there was no opportunity or incentive for power generation in the sugar factories but with the advent of liberalization, the country is on the threshold of exciting growth opportunities in this sector.

A final thought by way of conclusion. In the US, the PURPA (Public Utilities Regulatory Policies Act) regulatory mechanism was introduced keeping two basic objectives in view: (i) to achieve better utilization of fossil fuel energy through cogeneration (70–90% *vs* 34%); and (ii) to encourage the use of renewable sources of energy. This policy succeeded beyond expectations and resulted in the addition of 60 000 MW of installed capacity from small generators within a decade. During this period there was very little or no addition of conventional fossil fuel capacity by the utilities as there was no further need. If the US with all its resources can opt for this route, why can't we look at such options with serious enthusiasm?

Exploitation of renewable energy sources: incentives for private entrepreneurs in the state of Karnataka

B R Jagan

Mini hydel and small hydel

The KPCL (Karnataka Power Corporation Limited) is the agency for investigation of hydel (including micro hydel) projects. As per the latest policy of the government, the execution of almost all mini and micro hydels is left to the private sector except a few projects where the Irrigation Department prefers KPCL to execute directly on technical and administrative grounds.

Incentives for private participation

To encourage private sector participation in these schemes, a number of incentives have been provided by the central and state governments.

Central government incentives

1. All private companies entering the electricity sector will be allowed a debt–equity ratio of 4:1. They will be permitted to raise up to a minimum of 20% of the total outlay through public issues. The promoters' contribution should be at least 11% of the total outlay, and not more than 40% of the total outlay can come from Indian public finance institutions.
2. Up to 100% foreign equity participation can be permitted for projects set up by foreign investors in the case of licensees and generating companies.

3. With the approval of the government, import of equipment for power projects will also be permitted in cases where foreign supplier(s) or agency(ies) extend concessional credit.
4. The Indian Electricity Act and the Electricity (supply) Act have been amended to bring about a new legal and financial environment for private enterprises in the electricity sector. However, schemes where total outlay does not exceed Rs 100 crores need not be submitted to the Central Electricity Authority (CEA) for their concurrence.
5. Specific incentives for licensees are:
    (i) Licenses of a longer duration (40 years);
    (ii) Higher rate of return (5% in place of 2% above RBI rate); and
    (iii) Capitalization of interest during construction (IDC) at actual cost (for expansion projects also) as against 1% over the present RBI rate.

State government incentives

1. Power generated by the private developers may be:
    (i) Sold to the KEB (Karnataka Electricity Board) at a suitable negotiated tariff;
    (ii) Sold to a consumer of their choice; and
    (iii) Stored for their captive use.

    The KEB will arrange for the wheeling and banking of energy through its T & D (transmission and distribution) system from the point of generation by the private firm to the point of consumption of power. For this purpose, it will levy wheeling and banking charges at the rate of 2% of energy generated up to 1 MW, 5% from 1 MW to 3 MW, and 10% in other cases. The banking will be on water-year basis with a grace period of one month.
2. Electricity tax on power generation for self-consumption will be exempted for 5 years in case of new industrial units.
3. All incentives given to new industrial units by the state government as per government order no. Cl. 138 SPS 90(P) dated 21.10.90 will be extended to new private sector small hydel projects.
4. The land requirement for development of mini hydel schemes allotted to private developers will be acquired by the KIADB (Karnataka Industrial Area Development Board) and handed over to private developers along with their terms and conditions in case of revenue lands. In the case of lands under the Irrigation Department, permission will be obtained by the KPCL and private developers will be permitted to develop the mini hydel and small hydel projects.

State's terms of lease

1. A nominal fee of Rs 1000 per annum will be charged for the duration of the lease which allows private ownership of the mini hydro facilities to be extended over a 40-year period.
2. A royalty for use of water will be charged at the rate of 10% of the prevailing electricity tariff for HT (high tension) industrial consumers.
3. Statutory levies applicable to the KPCL and the KEB will be levied from time-to-time.
4. The cost of installing a transmission line to connect the mini hydro scheme to the state grid for power evacuation will have to be borne by the private company.

Loan assistance

The MNES (Ministry of Non-conventional Energy Sources) through the IREDA (Indian Renewable Energy Development Agency) will arrange for loans for the developers who can mobilize at least 25% of the estimated cost of small/mini hydel projects.

Wind energy

The assessed wind energy potential of Karnataka so far is about 200 MW. Sites have been identified for about 100 MW at eight locations.

As per the present policy, the Karnataka government through the KPCL is encouraging private developers to invest in developing windfarms by providing additional incentives to those provided by the government of India.

Incentives for private sector participation

Central government incentives

- The wind electric generators can be imported under open general license. However, to encourage indigenization of wind turbine technology, some major components are exempted from excise duty through Custom Notification No. 89–91 Customs, dated 25.7.91, and No. 89–92 Customs, dated 1.3.92.
- Under the Income Tax Act, the government of India is allowing 100% depreciation in the very first year of commissioning of the windfarm vide Section 32 Rules (5) Appendix-1 of the Income Tax Act, 1961.

State government incentives

- The WEG (wind electric generators) can be connected to a grid and the KEB will wheel power to the location where it is to be consumed. For this purpose, the KEB will deduct 2% as commission for wheeling and banking of the power generated and transmitted by the windfarm irrespective of its capacity.
- Private developers are allowed to generate power from windfarms and either keep it for their captive use or sell it to their customers or the KEB at negotiated rates.
- All incentives now available to new industrial units will be available for wind energy projects as well.
- Wind energy projects are exempted from electricity tax on power generated for their own consumption.

Conditions

- The entire cost of interfacing a windfarm with the nearest grid sub-station including the cost of metering HT lines, feeders at the sub-station and windfarm end, etc., will have to be borne by the developer. The KEB can take it up as a deposit contribution work.
- Two separate energy meters, one for import and one for export from the KEB grid will have to be installed on the HT side at the cost of the developer. The meters will be sealed by the KEB.
- The starting current of the WEG should not exceed the full load current of the machine and necessary current limiting devices like thyristors have to be provided by the developer at his cost.
- A capacitor of sufficient rating should cut in automatically so that the power factor is always maintained above 0.8.
- The WEGs should cut-off automatically whenever the grid fails.

Loan assistance

The MNES through the IREDA will arrange for loans for those developers of windfarms who can mobilize at least 25% of the estimated project cost.

Wind power estate (joint venture)

To help small entrepreneurs who cannot invest large sums of money towards infrastructure, the MNES has introduced the concept of formation of joint sector company will be the private developer, state government or its Boards or Corporations and the IREDA with equity capital of 51%, 25% and 24%, respectively.

Function of the joint sector company

The joint sector company will function as a single coordinated arrangement. All concerned agencies will be on the Board of the company which will serve as a 'Single Window' for all aspects of the project up to commissioning including post-installation services. It will deal with the following specific aspects:

- Identification of locations and pre-feasibility studies
- Survey and investigation
- Preparation of detailed project reports
- Acquisition of land on lease and its development
- Development of infrastructure including plots, approach roads, water sources, sub-stations, grid interfacing facilities, and erection of equipment
- Procurement of materials and equipment
- Execution, O&M and post-installation services
- Mobilization and management of financial resources
- Obtaining necessary clearances from state agencies

Noteworthy features of the joint venture approach

- Small investors will not have to go through problems of land acquisition, site development, grid extension, etc.
- They will not have to prepare detailed project reports and tender documents, and arrange for procurement and installation.
- The cost of individual turbines is likely to be lower due to possibilities of large scale procurement and lower overhead costs because of availability of developed infrastructure and organized planning and implementation.
- Streamlined arrangements for applications and availing of loans from financial institutions such as the IREDA will be possible.
- Facilities will be available for efficient and smooth operation and maintenance of wind turbines at a lower cost by trained personnel.
- Progressive capacity addition will be easier and cheaper.
- Central stock of spares and timely services of trained personnel for replacement and repair will be available.

SECTION C

Program schedule

Agra

27 January 1995

1015–1145 hrs. ***Introductory session (Overview and goals)***

Ajit Gupta
Keith Kozloff
V V N Kishore

1145–1200 hrs. Tea/Coffee

1200–0100 hrs. ***Policies affecting renewable power development***

Private Utility:	George St John Philip DiVirgilio P K Sen
Moderator:	Leena Srivastava

0100–0145 hrs. Lunch

0145–0245 hrs. ***Policies affecting renewable power development*** (contd.)

Public Utility:	Andrew Vesey T Chikkoba
Moderator:	Arun Kumar

0245–0300 hrs. Tea/Coffee

0300–0430 hrs. ***Role of private industry in technology commercialization***

George Sterzinger
B C Jain
Rakesh Bakshi
Moderator: Venkata Ramana P

0430–0530 hrs. ***Renewables for DSM (demand-side management) and DU (distributed utility) applications***

T C Tripathi
Pascal De Laquil
Moderator: Somnath Bhattacharjee

28 January 1995

0900–1100 hrs. ***Role of federal, state, and local policy tools for commercial development and renewable power generation***

Gary Nakarado
V Bhakthavatsalam
Moderator: Arun Kumar

1100–1115 hrs. Tea/Coffee

1115–0115 hrs. ***Effects of alternative forms of power sector restructuring on market prospects for renewables***

Jan Hamrin
Leena Srivastava
Moderator: Arun Kumar

0115–0200 hrs. Lunch

0200–0300 hrs. ***Legislative proposals for India***

Group 1: Renewables for power generation
Group 2: Rural energy applications
Group 3: DSM and DU

0300–0315 hrs. Tea/Coffee

0315–0530 hrs. ***Concluding Session***

R K Pachauri, Chairman
Group presentations
Dick Goldman, USAID

New Delhi

30 January 1995

0930–1000 hrs. ***Registration***
1000–1045 hrs. ***Inaugural Session***

L M Menezes
R K Pachauri
Keith Kozloff

1045–1100 hrs. Tea/Coffee

1100–1200 hrs. ***Renewable power development***

Leena Srivastava

1200–0100 hrs. ***Rural energy applications***

V V N Kishore

0100–0145 hrs. Lunch

0145–0315 hrs. ***Demand-side management and distributed utilities***

Arun Kumar

0315–0330 hrs. Tea/Coffee

0330–0500 hrs. ***Concluding Round Table***

Presentation: Venkata Ramana P

Panel:
S Krishna Kumar, Minister of State, MNES
Frank Wisner, US Ambassador to India
L M Menezes, Secretary, MNES
R K Pachauri, Director, TERI

0500–0510 hrs. ***Vote of thanks***: Venkata Ramana P

List of Participants

Agra

R R Bakshi
Chairman
RRB Consultants and Engineers Pvt Ltd
161, Sukhdev Vihar
New Delhi-110 025
Phone: 6848228, Fax: 011-6835160

V Bhakthavatsalam
Managing Director
Indian Renewable Energy Development Agency
Core 4-A, East Court, I Floor
India Habitat Centre
Lodhi Road, New Delhi-110 003
Phone: 4601344, Fax: 011-4602855

Somnath Bhattacharjee
Fellow & Dean, Energy Engineering and Technology Division
Tata Energy Research Institute
Darbari Seth Block
Habitat Place
Lodhi Road, New Delhi-110 003
Phone: 4622246/4601550
Fax: 011-4621770/4632609

T Chikkoba
Consultant
Tamil Nadu Electricity Board
M-43, Anna Nagar
Madras-600 102
Phone: 044-6261109

T V Chowdary
Managing Director
Non-conventional Energy Development Corporation of Andhra Pradesh
5-8-207/2, Piagah Complex, Nampally
Hyderabad-500 001
Phone: 040-202381, Fax: 040-201666

M K Deb
Director
Consolidated Energy Consultants Limited
27 Maharana Pratap nagar, Zone II
Bhopal-461 011
Phone: 0755-553681
Fax: 0755-550481

Ajit K Gupta
Director (Power)
Ministry of Non-conventional Energy Sources
Block 14, CGO Complex
Lodhi Road
New Delhi-110 003
Phone/Fax: 011-4361152

B R Jagan
Chief Engineer (I & RE)
Karnataka Power Corporation Limited
118/2, I Floor, Trade Centre
Race Course Road
Bangalore-560 001
Phone: 2268431, Fax: 080-2262144

B C Jain
Ankur Scientific Energy Technologies Pvt Ltd
Near Old Sama Jakat Naka
Baroda-390 008
Phone: 481021/481098
Fax: 0265-481042

Gulshan Kapur
President
Advanced Electronic Systems
40, DSIDC Complex
Okhla Phase I, New Delhi-110 020
Phone: 6812802, Fax: 011-601438

V V N Kishore
Senior Fellow
Tata Energy Research Institute
Darbari Seth Block, Habitat Place
Lodhi Road, New Delhi-110 003
Phone: 4622246/4601550
Fax: 011-4621770/4632609

Arun Kumar
National Project Coordinator
UNDP/GEF India Hilly Hydro Project
Tata Energy Research Institute
Darbari Seth Block, Habitat Place
Lodhi Road, New Delhi-110 003
Phone: 4622246/4601550
Fax: 011-4621770/4632609

Raj Kumar Khemka
Director
NEPC-Micon limited
36, Wallajah Road, Madras-600 002
Phone: 8525870/8524541
Fax: 044-8522553

Sudheer Mohan
Director
Ministry of Non-conventional Energy Sources
Block 14, CGO Complex
Lodhi Road, New Delhi-110 003
Phone: 4362621, Fax: 4361152

Anand Narayanan
Executive Director
Esquire Energy Limited
Commerce Centre 1, World Trade Centre
Unit no 3, 17th Floor, Cuffe Parade
Colaba, Bombay-400 005
Phone: 022-2189949
Fax: 022-2189951

R K Pachauri
Director
Tata Energy Research Institute
Darbari Seth Block, Habitat Place
Lodhi Road, New Delhi-110 003
Phone: 4622246/4601550
Fax: 011-4621770/4632609

M B V Rajan
Consultant
Bhoruka Power Corporation Limited
Flat no 15, Chitrakoot Apartments
Malleswaram West, Bangalore-560 055
Phone: 3342019, Fax: 080-2270605

Venkata Ramana P
Fellow & Dean
Rural Energy Division
Tata Energy Research Institute
Darbari Seth Block, Habitat Place
Lodhi Road, New Delhi-110 003
Phone: 4622246/4601550
Fax: 011-4621770/4632609

P K Sen
Director
Thermax
4, Bombay Pune Road
Shivaji Nagar, Pune-400005
Fax: 0212-323226

Anil Sethi
Chairman
Subhas Projects and Marketing Limited
F-27/2, Okhla Industrial Area-Phase II
New Delhi-110 020
Phone: 011-635114/6844980

A R Shukla
Director
Ministry of Non-conventional Energy Sources
Block 14, CGO Complex
Lodhi Road
New Delhi-110 003
Fax: 4361298

K K Singh
Director
Ministry of Non-conventional Energy Sources
Block 14, CGO Complex
Lodhi Road
New Delhi-110 003
Fax: 011-4361298

Leena Srivastava
Fellow & Dean
Policy Analysis Division
Tata Energy Research Institute
Darbari Seth Block
Habitat Place
Lodhi Road
New Delhi-110 003
Phone: 4622246/4601550
Fax: 011-4621770/4632609

T C Tripathi
Director
Ministry of Non-conventional Energy Sources
Block 14, CGO Complex
Lodhi Road, New Delhi-110 003
Fax: 011-4361298

Philip DiVirgilio
Director, Wind Turbine Marketing
Zond Energy Systems, Inc
P O Box 1910
13000 Jameson Road
Tehachapi, CA 93561
Phone: 805-822-6835
Fax: 805-822-7880

Jan Hamrin
Principal
Hansen, McOuat
Hamrin & Rohde Inc
50 California Street
Suite 3005
San Francisco, CA 94111
Phone: 415-397-2210
Fax: 415-391-1329

Keith Kozloff
Senior Associate
Climate, Energy and Pollution Program
World Resources Institute
1709 New York Avenue, NW
Washington, DC 20006
Phone: 202-638-0036
Fax: 202-638-6300

Gary Nakarado
Technical Director for Utility Programs
National Renewable Energy Laboratory
1617 Cole Boulevard, 17-3
Golden
Colorado 80401
Phone: 303-275-3393
Fax: 303-275-3097

George St John
Vice President of Plant Operations and Planning
AMFAC/JMB Hawaii, Inc
P O Box 3236
Honolulu, HI 96801
Phone: 808-543-8543
Fax: 808-543-8545

George Sterzinger
Future Energy Resources Corporation
3350 Cumberland Circle, NW
Suite 1500
Atlanta
GA 30339-3363
Phone: 404-612-5575
Fax: 404-612-5560

Andrew Vesey
Vice President of Power Delivery
Niagara Mohawk
300 Erie Boulevard West
Syracuse, New York 13202
Phone: 315-428-6765
Fax: 315-428-5566

Pascal De Laquil
Bechtel Corporation
50 Beale Street
San Francisco, CA 94105
Phone: 415-768-1947
Fax: 415-768-0503

Roger Wagner
Attorney, USA

David Hess
Energy/Environment Program
US Agency for International Development
B-28, Qutub Institutional Area
New Delhi-110 016
Phone: 6865301
Fax: 91-11-6868594

Dick Goldman
Energy/Environment Program
US Agency for International Development
B-28, Qutub Institutional Area
New Delhi
Phone: 6865301
Fax: 91-11-6868594

New Delhi

US Participants
Vikram Dalal
Iowa State University
Ames, Iowa

Philip DiVirgilio
Zond Corporation
California

Y C Goyal
NMPC
Syracuse, New York

Jan Hamrin
Principal
Hansen
McOuat
Hamrin & Rohde Inc
San Francisco

George St John
Vice President
AMFAC/JMB
Honolulu, Hawaii

Keith Kozloff
Senior Associate
World Resources Institute
Washington, DC

Mathew Mendis
President
Alternative Energy Development
Silverspring, Maryland

Gary Nakarado
Technical Director
National Renewable Energy Laboratory
Golden, Colorado

Carol Pierstorff
United States Agency for International Development
Washington, DC

Frederick Renner
Vice President
Econergy
Denver, Colorado

George Sterzinger
FERCO
Washington, DC

Harin Ullal
National Renewable Energy Laboratory
Golden, Colorado

Andrew Vesey
Vice President
Niagara Mohawk
New York

Roger Wagner
Attorney, USA

Government/Public Sector Organizations

S N Akhauri
Director
Bihar Renewable Energy Development Agency
Patna

G Babu
Assistant Director
Bureau of Indian Standards
New Delhi

V Bakthavatsalam
Managing Director
Indian Renewable Energy Development Agency
New Delhi

Jagdish Chandra
Director
Bureau of Indian Standards
New Delhi

T V Chowdary
Managing Director
Non-conventional Energy Development Corporation of Andhra Pradesh
Hyderabad

P K Dwivedi
Executive Director
Power Grid Corporation of India
New Delhi

Seema Gupta
Deputy Chief Design Engineer
Power Grid Corporation of India
New Delhi

D V Gupta
Chairman and Managing Director
Central Electronics Limited
Sahibabad (UP)

B R Jagan
Chief Engineer (I & R E)
Karnataka Power Corporation Limited
Bangalore

M P Jindal
Director
Rajasthan Electronics and Instruments Limited
Jaipur

C L Kalsi
Director
Press Information Bureau, New Delhi

Ashok Kashyap
Chief Engineer
Haryana State Electricity Board
Chandigarh

B S K Naidu
General Manager
Indian Renewable Energy Development Agency
New Delhi

Binu Parthan
Research Fellow
Indian Renewable Energy Development Agency
New Delhi

S M C Pillai
Director
National Thermal Power Corporation
New Delhi

R Rajappa
Chairman and Managing Director
Water and Power Consultants
New Delhi

A R G Rao
Director
Central Board for Irrigation and Power
New Delhi

Private sector

Rakesh Bakshi
RRB Consultants & Engineers
New Delhi

Akanksha Chaurey
Sairam Solar
New Delhi

Gulshan Kapur
Advanced Electronic Systems
New Delhi

Sunil Mehra
Siemens
New Delhi

N K Rawat
Director (Sugar)
Agauta Sugars and Chemicals
New Delhi

Pradeep Sethi
Director
Sethi and Grover Associates
New Delhi

Virendra Singh
Deputy Secretary
ASSOCHAM, New Delhi

P V Soni
Sairam Solar
New Delhi

A K Vora
Managing Director
Tata BP Solar Limited, Bangalore

Academic/Research/Consulting/Aid Organizations

Brijesh Chandra
Director
Water Resources Development Training Centre
University of Roorkee, Roorkee

Ramesh Chanduar
Researcher
Indian Institute of Public Administration
New Delhi

Koshy Cherail
Centre for Science and Environment
New Delhi

Dick Goldman
United States Agency for International Development
New Delhi

S Gopinath
Director
National Productivity Council
New Delhi

A J Goulding
Energy Consultant
United States Agency for International Development
New Delhi

David Hess
United States Agency for International Development
New Delhi

C M Jain
Power and Energy Consultants
New Delhi

Veena Joshi
Program Officer
Swiss Development Cooperation
New Delhi

Arun Kumar
Scientist C
Alternate Hydro Energy Centre
University of Roorkee, Roorkee

Rashmi Naik
Consultant
JPS Associates
New Delhi

B Prasad
Scientist
Alternate Hydro Energy Centre
University of Roorkee
Roorkee

N V Seshadri
United States Agency for International Development
New Delhi

J D Sharma
Director
Alternate Hydro Energy Centre
University of Roorkee, Roorkee

Ron Somers
United States Agency for International Development
New Delhi

B Sudhakara Reddy
Associate Professor
Indira Gandhi Institute for Development Research
Bombay

M C K Swamy
JPS Associates
New Delhi

Tata Energy Research Institute

S Bhattacharjee
Fellow & Dean
Energy Engineering and Technology

P K Dadhich
Fellow
Energy Engineering and Technology

V V N Kishore
Senior Fellow
Energy Engineering and Technology

Arun Kumar
National Project Coordinator
UNDP/GEF Micro Hydel Project

Sameer Maithel
Research Associate
Rural Energy Research and Extension

Sanjay Mande
Research Associate
Energy Engineering and Technology

R K Perumal
Research Associate
Energy Engineering and Technology

N S Prasad
Research Associate
Energy Engineering and Technology

Lalit Rai
Research Associate
Rural Energy Research and Extension

Venkata Ramana P
Fellow & Dean
Rural Energy Research and Extension

Dilip Singh
Research Associate
Rural Energy Research and Extension

S N Srinivas
Research Associate
Rural Energy Research and Extension

Leena Srivastava
Fellow & Dean
Policy Analysis

Ministry of Non-conventional Energy Sources
Suresh Agarwal
Principal Scientific Officer

Bibek Bandopadhyay
Director

H K Dash
Deputy Secretary

B M L Garg
Principal Scientific Officer

A K Gayen
Director

Ajit K Gupta
Director

K C Khandelwal
Advisor

Sudheer Mohan
Director

U N Panjiar
Joint Secretary

S Ranganathan
Joint Secretary

E V R Sastry
Advisor & Head (SEC)

A R Shukla
Director

K K Singh
Director

N P Singh
Director

Concluding Panel
S Krishna Kumar
Minister of State for Non-conventional Energy Sources

Frank Wisner
US Ambassador to India

L M Menezes
Secretary
Ministry of Non-conventional Energy Sources

R K Pachauri
Director
Tata Energy Research Institute

Biographical sketches of the US participants

Philip J DiVirgilio

He is responsible for the marketing of Zond's Z-Class family of advanced technology wind turbines as well as its lines of wind turbine controllers, data recorders, and supervisory controls and data acquisition systems. DiVirgilio has experience in energy-related industries with a particular emphasis on independent power projects in California since the inception of PURPA legislation by the federal government. This includes management of a portfolio of independent power projects in California with a major focus on the two largest solar generating projects in the world.

DiVirgilio has served as the President and Chief Operating Officer of a 25 MW gas-fired facility in California, which also included an agricultural drying operation as the thermal host. He has handled governmental and regulatory affairs covering California for a firm that was a developer, engineer, owner, and operator of cogeneration facilities. As part of that role he served as the Chairman of the Board of the Independent Energy Producers, a Californian association set up to promote the interests of alternative energy technologies which included cogeneration, solar, wind, geothermal, and biomass energy. In addition, he served on the executive committee of the California Cogeneration Council, an ad hoc group of gas-fired cogenerators who intervene in cases before the Public Utility Commission. DiVirgilio has also been on the manufacturing side of the business where he was a Product Line Manager for a turbomachinery company providing components and systems for cogeneration facilities.

Jan Hamrin

Dr Jan Hamrin is a principal of Hansen, McOuat, Hamrin & Rohde, a San Francisco consulting firm specializing in energy and financing of alternative energy projects. For the past few years, Hamrin has been focusing her attention on issues of renewable resource integration into the utility system. She has co-authored two books: *Affected with the Public Interest: Electric Industry Restructuring in an Era of Competition*, 1994 and *Investigation in the Future: A Regulator's Guide to Renewables*, 1993.

Hamrin founded and served as the Executive Director of the Independent Energy Producers Association in California and the National Independent Energy Producer's Association in Washington, DC. Before that she served as Manager of Solar Programs for the California Energy Commission and as the Director of the University of California Energy Extension Service.

Hamrin received her PhD in ecology from the University of California at Davis, with emphasis on public policy evaluation of environmental and energy programs. She also holds Masters degrees in Public Administration and Consumer Science.

George Edward St John P E

George St John has worked for most of his professional career in sugar and energy project development. He has an electrical engineering background and over 25 years experience in sugar industry power projects. His most recent project involvement was the 60 MVA waste-to-energy project for the city of Honolulu. He has provided energy development and power sales assistance to developers throughout the world. He is frequently a legislative and regulatory spokesman for the independent power industry.

Keith Kozloff

Dr Keith Kozloff is a Senior Associate in the Climate, Energy, and Pollution Program at the World Resources Institute (WRI). Kozloff is the principal author of the WRI publications *A New Power Base: Renewable Energy Policies for the 90s and Beyond* and *Rethinking Development Assistance for Renewable Electricity*. He is currently conducting collaborative research on international mechanisms to commercialize renewable energy technologies, energy policy in developing countries, and strategies to make the US power sector more sustainable.

Kozloff also worked for six years for the state of Minnesota's energy office. During that period, he managed the evaluation of energy conservation and renewable energy programs. He has an MS in Planning from the University of Wisconsin and a PhD in Agricultural Economics from the University of Minnesota.

Pascal De Laquil, III

Dr De Laquil is a project manager within Bechtel Corporation's Research and Development Organization and is responsible for solar thermal commercialization activities. He is currently on a special assignment to prepare a business plan for an international company to develop distributed generation and energy efficiency projects.

He has been at Bechtel for over 10 years and was the Renewable Energy Technology Manager for seven years. During that time he was responsible for securing Bechtel's participation on the Solar Two Project and the PVUSA Project. He was the project manager for the Solar Central Utility Studies and for Bechtel's activities with the PHOEBUS European Central Receiver Consortium.

De Laquil is the author of over 25 papers, reports, and articles on solar energy, including 10 technical reports on solar central receiver technology. He is a member of the American Solar Energy Society, the International Solar Energy Society, and the American Society of Mechanical Engineers. He is currently the Chairman of the Solar Thermal Power Division of the Solar Energy Industries Association.

Gary L Nakarado

Gary Nakarado is the Technical Director for Utility Programs at the Department of Energy's NREL (National Renewable Energy Laboratory), Golden, Colorado. Prior to this, he served for four years as a Colorado Public Utilities Commissioner, and was active at the state, regional and national levels. During his term as Commissioner, Nakarado initiated the adoption of an integrated resource planning rule, and also policy developments in the Electromagnetic Fields and alternative forms of regulation. He also served as the Vice Chairman of the NARUC Committee on Energy Conservation. His special interests are in energy policy, telecommunications, and in communications and systems theory, especially in negotiations, conflict resolution and quality. Nakarado graduated from the University of Michigan Law School and also has a Bachelor of Arts degree with special honors in Economics from the University of Chicago.

George Sterzinger

George Sterzinger brings experience from several perspectives to renewable energy technology development. From 1988 to 1991, Sterzinger ran the Energy Planning and Regulatory Policy Department of the State of Vermont. Long-range energy planning, environmental mitigation, and renewable technology development were critical components of state policy during this time.

More recently, Sterzinger undertook the initial feasibility study that led to the creation of a solar energy development authority at the Nuclear Test Site Facility at Nevada. That project has enjoyed stunning success to date: it is about to issue the first request for proposals inviting solar technologists to initiate commercial projects at the site. The project demonstrates the potential of public–private commercialization ventures.

Finally, Sterzinger works for Future Energy Resources Company which is commercializing the Battelle Labs biomass gasifier. He is responsible for developing biomass-to-electric markets for the technology. An initial commercial project is currently being permitted. Follow-on projects are under negotiation in several US and international markets.

Andrew M Vesey

A native of New York city, Vesey holds a BA and BSME from Union College and an MS from the New York University. He began his career as an engineer with Consolidated Edison Company of New York, moved to the New York State Energy Research and Development Authority as Senior Project Manager, and joined the Niagara Mohawk Power Corporation in 1984 as Manager of Generation research. He was promoted to Director of R & D in 1987, and elected as an officer of the corporation in June 1991.

From August 1989 until he was elected Vice President—Operations Support, he was assigned full-time to Niagara Mohawk's self-assessment team, playing a lead role in the development of a comprehensive change program for the corporation.

He was elected Vice President–Power Delivery in November 1994, and is responsible for a department that provides engineering, construction, operation, and maintenance services for over 7500 pole miles of transmission and more than 900 substations. His department also provides O & M services for the company's 75 hydroelectric facilities, as well as management of the company-wide electric research and development program.

Vesey has served as an advisor to the Electric Power Research Institute and the Brookhaven National Laboratory, Applied Science Division. He has been a Director of the Empire State Electric Energy Research Corporation. He is currently Chairman of the Utility Photovoltaic Group Board of Directors, and a member of the Director's Council of the Lighting Research Center, the Edison Electric Institute's Engineering and Operating Standards Advisory Committee, the Asian Pacific Economic Cooperation Utility DSM Liaison Group, and the American Society of Mechanical Engineers.

Appendix

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